CHAPTER 12

CRANES AND ATTACHMENTS

Cranes and attachments are essential to the support of Naval Construction Force (NCF) operations. Lifting heavy objects, loading and unloading construction materials, excavating earthwork materials, and driving and extracting piles are typical tasks accomplished by the use of cranes and attachments.

Cranes and attachments procedures are a complex set of characteristics. Proper and efficient operation of cranes and their attachments requires more knowledge and skill than for any other piece of construction equipment you will operate.

NOTE: You must always be exceptionally safety conscious when working on or around crane operations of any type.

This chapter covers the characteristics and basic principles of operations of cranes and attachments. By reading the operator's manual and attending crane school, you can obtain detailed information about crane operations.

CRANES

Cranes are classified as **weight-handling equipment** and are designed primarily to perform weight-lifting and excavating operations under varied conditions. To make the most efficient use of a crane, you must know their capabilities and limitations.

TYPES OF CRANES

Cranes have evolved from many designs to satisfy the needs of construction and industrial operations. Operational characteristics of all cranes are basically the same. Although the superstructure is about the same on all makes and models of mobile cranes, the carrier, or mounting, may be one of three types: crawler, truck, or wheel (fig. 12-1).

Crawler-Mounted Cranes

The crawler-mounted crane is categorized under the 42-00000 USN number registration series. The crawler-mounted crane is slower and less mobile than the truck-mounted crane; however, the crawler-mount crane provides a stable base for operation of the revolving superstructure.

The travel unit of the crawler crane is shown in figure 12-2. The travel unit includes the base, travel gears, clutches, travel brakes, sprockets, rollers, crawler chains, and crawler treads. The revolving superstructure rotates on the turntable (fig. 12-3).

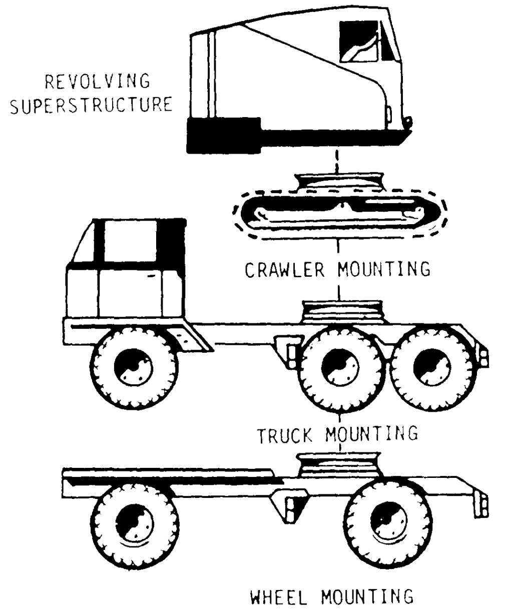


Figure 12-1.-Crane carrier mountings.

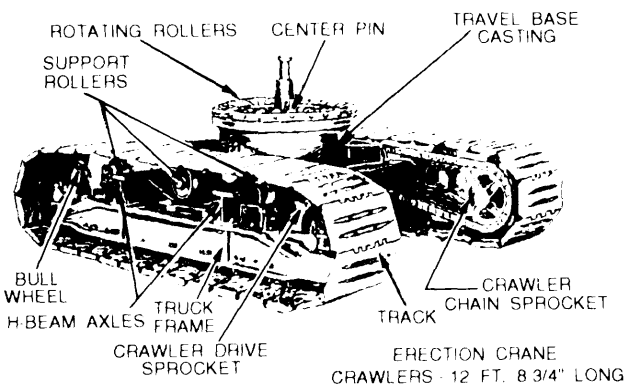


Figure 12-2.—Crawler crane travel unit.

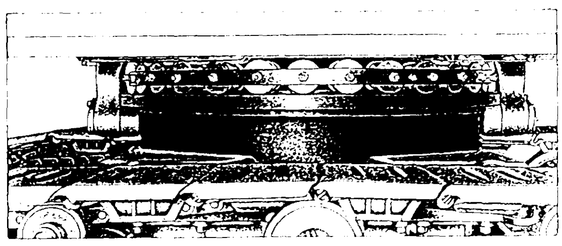


Figure 12-3.—Turntable assembly.

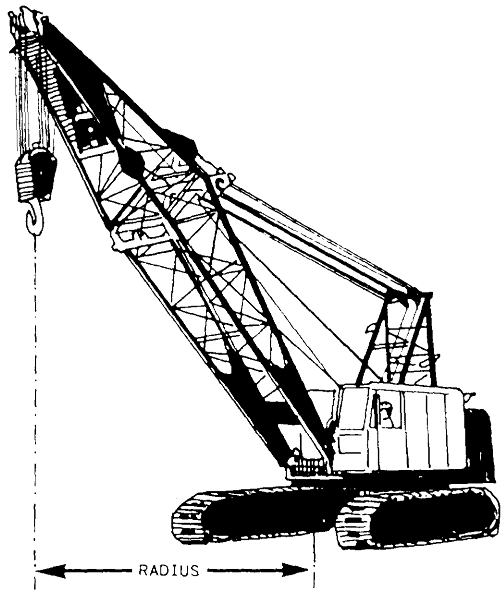


Figure 12-4.-Crane radius measurement.

The primary advantage of the crawler crane over the truck-mounted crane is that it is better suited for continuous work in remote areas that are not readily accessible to truck-mounted cranes because of terrain conditions. Also, the crawler crane has steering with positive traction that permits the crawler crane to travel and turn without cutting up the work area or roadway.

The size of the crawler treads spreads the weight of the crane over a large area. This feature gives the crawler crane a low ground bearing pressure of 5 to 12 psi, giving the crane the versatility needed to travel over soft terrain. When the crawler crane is climbing grades, the maximum grade capability is 30 percent on firm, dry material. The turning radius of the crawler crane is about the length of the tracks, which travel 1/2 to 2 mph. Because of the slow travel speed, it is not productive to try to travel more than 1 mile. Additionally, traveling the crane a long distance at one time causes extra wear to the tracks. When travel distance exceeds 1 mile, transport the crawler by tractor-trailer.

NOTE: Consult the operator's manual for detailed information if required to track travel for more than 1 mile,

Steering of the crawler crane is performed by engaging the steering lever in the direction you want the crane to turn. Some models of crawler cranes have a swing-travel jaw clutch that is controlled by one lever

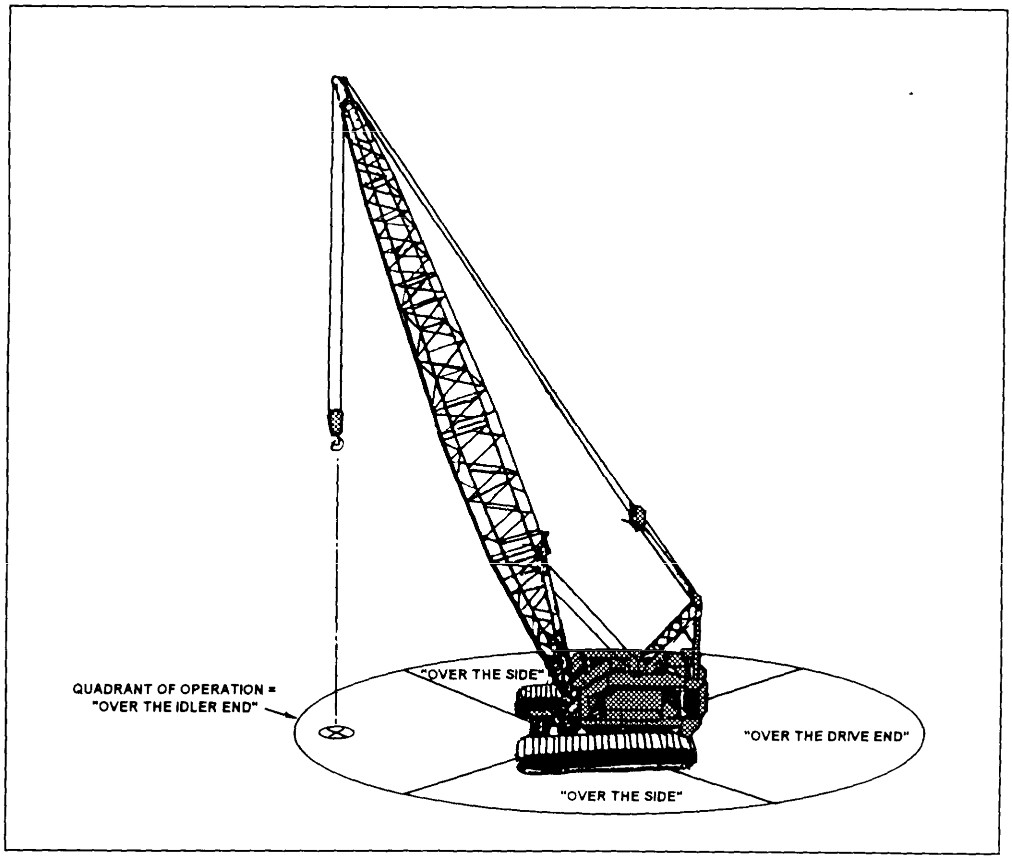


Figure 12-5.—Crawler-mounted crane quadrants of operation.

and provide power for either swinging the crane or traveling the crane. The swing-travel jaw clutch requires the operator to engage a button or push a lever to select for swing or travel operations. Other models have a separate steering and swing lever, allowing both functions to be operated at the same time.

Use caution when traveling with a crawler crane on and around slopes. Some older types of crawler cranes do not have travel brakes and power could be disengaged, causing the crawler to freewheel.

On-the-job maneuvering is easy because of the small turning radius of the crawler crane. Additionally, the crawler crane does not require the use of outriggers for stability, so it requires less room for setting up. On some models of crawler cranes, the tracks can extend outward, providing the crane with more stability. Crawler crane models, on which the crawler tracks can extend, are rated at 85 percent of the minimum weight that can cause the crane to tip at a specified radius with the basic boom, Crawler models that do not have extendable tracks are rated at 75 percent. Crane radius measurement is measured from the center of rotation to the center of the hook after the boom deflects forward when under load, as shown in figure 12-4.

Depending on the make and model, most crawler cranes have a 360-degree working area. This working area is divided into operating areas called **quadrants of operation.** The crane capacity is based on the quadrants, such as for over the side, over the drive end, and over the idler end, for a crawler-mounted crane (fig. 12-5). The capacity of the crane may change when rotating a load from one quadrant to another. This information is provided on the crane load chart.

Truck-Mounted Cranes

The truck-mounted crane (fig. 12-6) consists of a truck carrier and house (upper revolving unit) and is categorized under the 82-00000 USN number registration series. The truck carrier can travel from different jobsites at 20 to 35 mph.

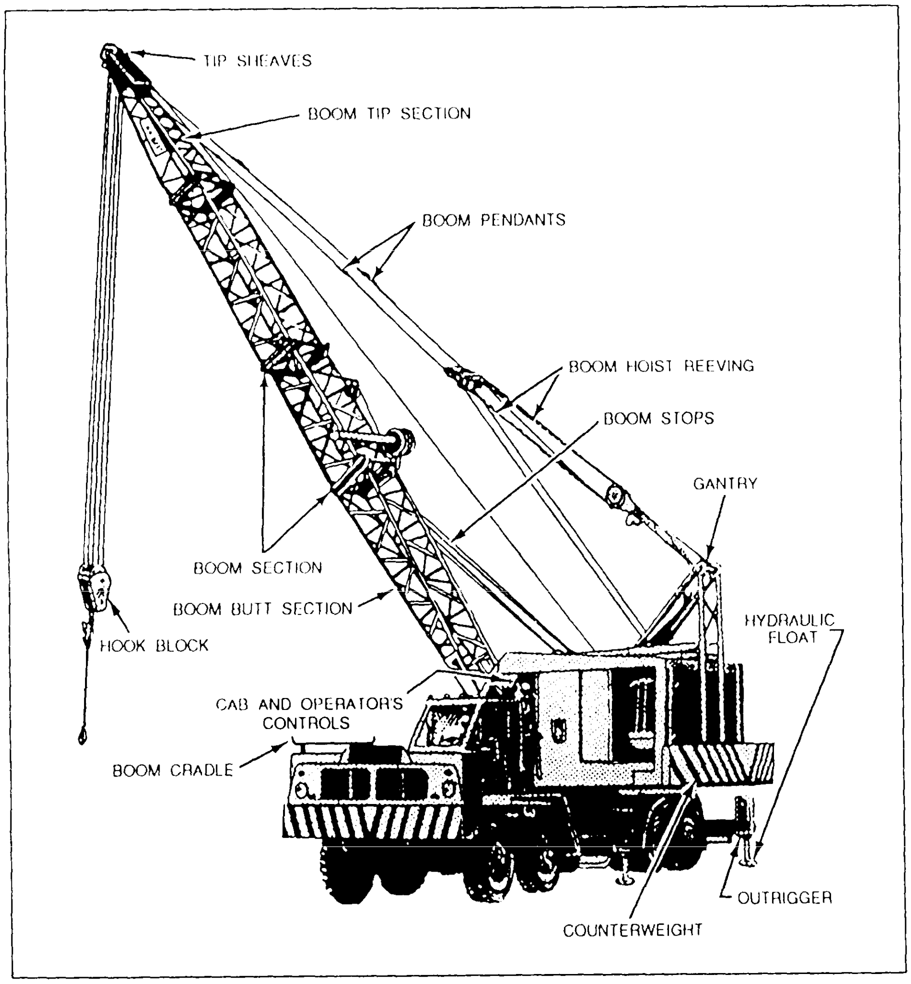


Figure 12-6.—Truck-mounted crane.

Truck cranes have a high ground bearing pressure, ranging from 75 to 100 psi due to the pneumatic tires on which the machine travels. On a firm, dry surface, a truck carrier can climb a 40-percent grade. Depending on the design of the carrier, the turning radius can range from 50 to over 90 feet. This high turning radius limits its maneuverability.

Before any crane travels to a jobsite, the crane crew supervisor must visually review the planned travel route to determine if low wires, low overpasses, narrow bridges, or other unsafe obstacles exist. The absolute limit of approach for power lines (fig. 12-7) is the following:

1. 0 to 125,000 volts, 10 feet
2. 125,000 to 250,000 volts, 15 feet
3. Over 250,000 volts, 25 feet

Anytime you are traveling with a crane, stay a minimum of 4 feet from any electrical power source.

When traveling with a truck-mounted crane equipped with a lattice boom, do NOT rest the boom on the cradle, as the lower cords of the boom can be dented if the boom bounces while traveling. Position the boom 2 to 4 inches above the cradle.

Truck- and wheel-mounted cranes are rated at 85 percent of the minimum weight that can cause the crane to tip at a specified radius with the basic boom. The truck carrier is equipped with outriggers that provide more stability for the crane; therefore, when you are making crane lifts, the outriggers should always be used.

As outlined in the COMSECOND/COMTHIRDNCBINST 11200.1, Naval Mobile Construction

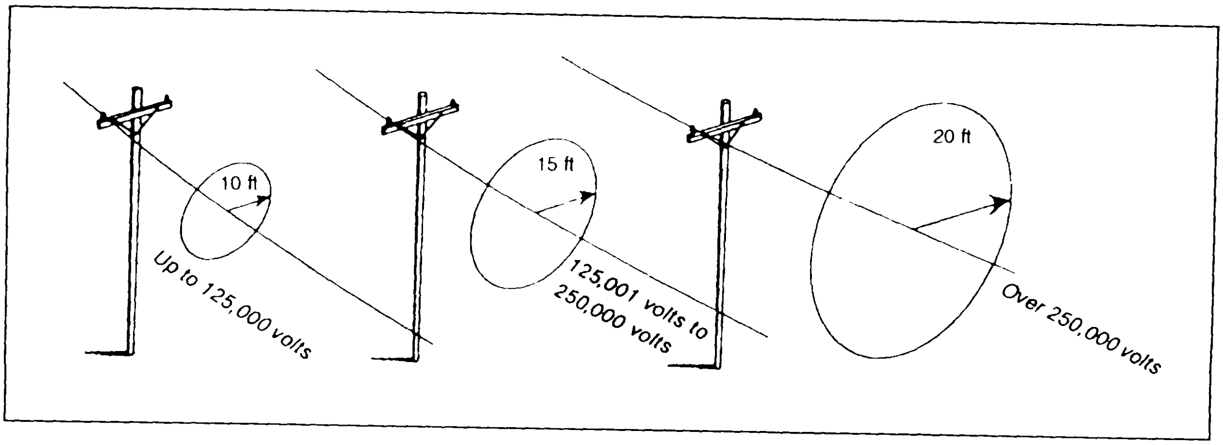


Figure 12-7.—Limit of approach for power lines.

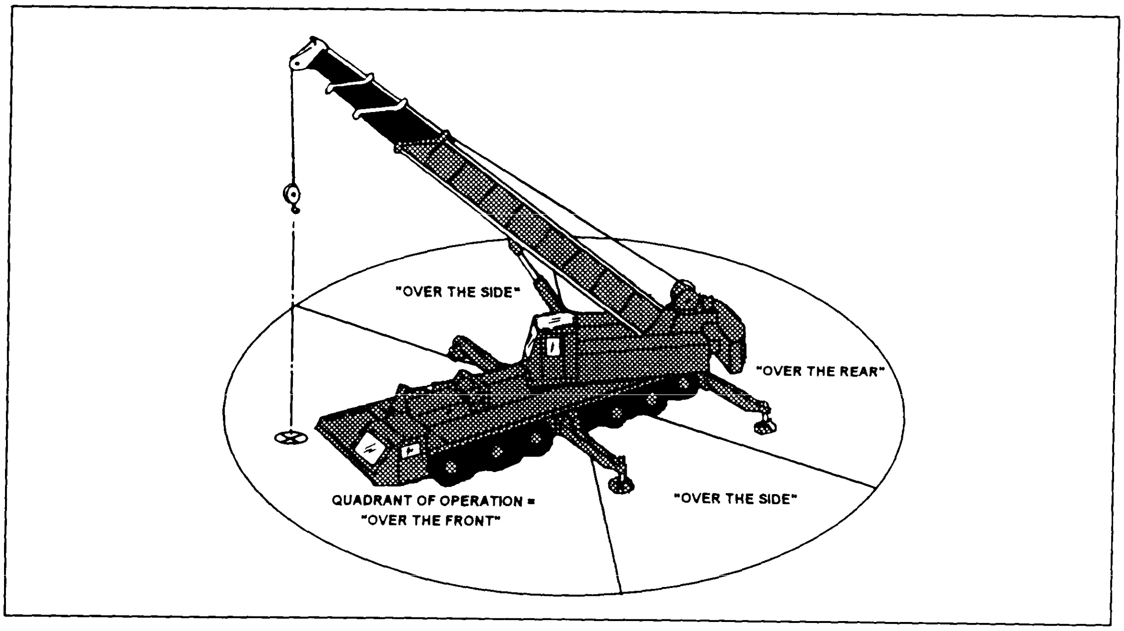


Figure 12-8.—Truck-mounted crane quadrants of operation.

Battalion, Equipment Management, rated free loads or pick and carry operations will only be performed according to NAVFAC P-307 during a crane certification, in case of an emergency, or as directed by the crane certifying officer.

Depending on the make and model, most truck-mounted cranes have a 270-degree working area. Some truck-mounted cranes are equipped with an optional front outrigger that provides a 360- degree working area The quadrants of operation for truck-mounted crones are over the side, over the rear, and over the front if equipped with the front outrigger (fig. 12-8).

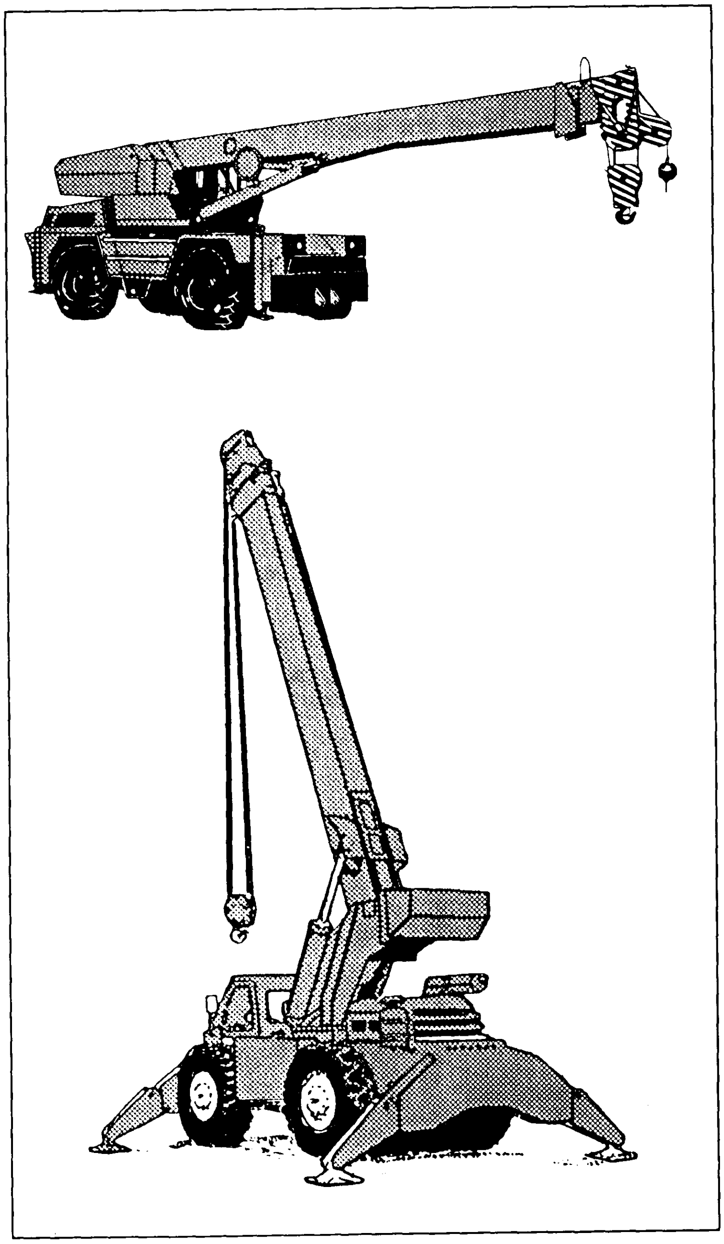


Figure 12-9.—Wheel-mounted cranes.

NOTE: The capacity of the crane may change when rotating a load from one quadrant to another. This information is provided on the crane load chart.

Wheel-Mounted Cranes

Wheel-mounted cranes range in various sizes and have capacities from 5 to 35 tons or larger (fig. 12-9).

The wheel-mounted cranes shown in figure 12-9 are hydraulically operated, four-wheel drive, four-wheel steer, pneumatic-tired, engine-powered diesel. The superstructure consists of a telescoping boom, single-acting hydraulic lift cylinders, a hydraulically operated hoist drum, and a hook block attachment.

The wheel-mounted crane has a ground bearing pressure of about 35 psi and can travel at speeds ranging from 2 to 30 mph. It can turn in a 30-foot radius with two-wheel steering and in a 17-foot radius with four-wheel steering and can travel up a firm, dry 40-percent grade.

The wheel-mounted crane is a mobile and flexible crane that can be driven on or off roads over rough terrain. It is best suited for lifts around shops or for supporting fabrication projects that call for many varied, mobile lifts within a small working area.

Depending on the make and model, most wheel-mounted cranes have a 360-degree work area The quadrants of operation for wheel-mounted cranes are over the side, over the rear, and over the front (fig. 12-10). **Remember** that the capacity of the crane may

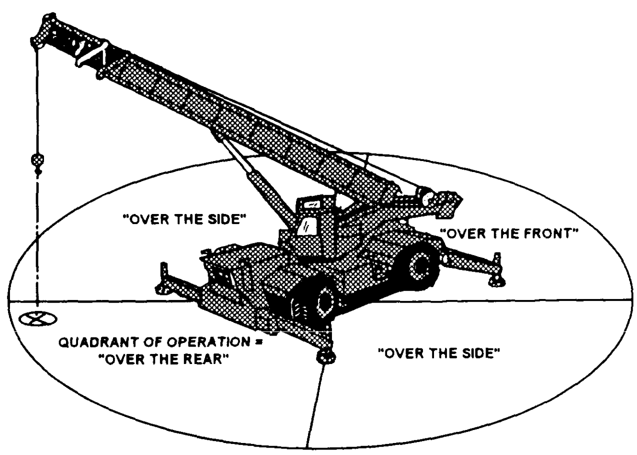


Figure 12-10.—Wheel-mounted crane quadrants of operation.

change when rotating a load from one quadrant to another. This information is provided on the crane load chart.

LATTICE BOOM CRANE

The major components of a lattice boom crane are shown in figure 12-11. Inspecting each of these components is part of the operator's prestart inspection.

The lattice boom supports the working load and is the most common boom used in the NCF. It is used on all types and makes of cranes and is mounted at the boom butt on the revolving superstructure. The basic boom consists of the boom butt and boom tip, and the length is increased by adding boom extensions.

Boom Sections

Lattice boom sections are made of lightweight, thin wall, high strength alloy tubular or angle steel and are designed to take compression loads. The most common boom is tubular. Terminology of a lattice boom section is shown in figure 12-12.

Manufacturers have set a zero tolerance on rust, bent lacings or cords, cracked welds, and other problems that affect the strength of the lattice boom. This zero tolerance requires crane crews to use extreme care when handling unused sections with forklifts, storing unused sections away from traffic areas, transporting and securing sections on tractor-trailers, and preventing equipment or obstacles from running into the boom while mounted on the crane during transport, performing operations, or when parked.

As outlined in the *Management of Weight-Handling Equipment, Maintenance and Certification,* NAVFAC P-307, all lattice boom cranes with structural damage to the main cords of the boom must be immediately

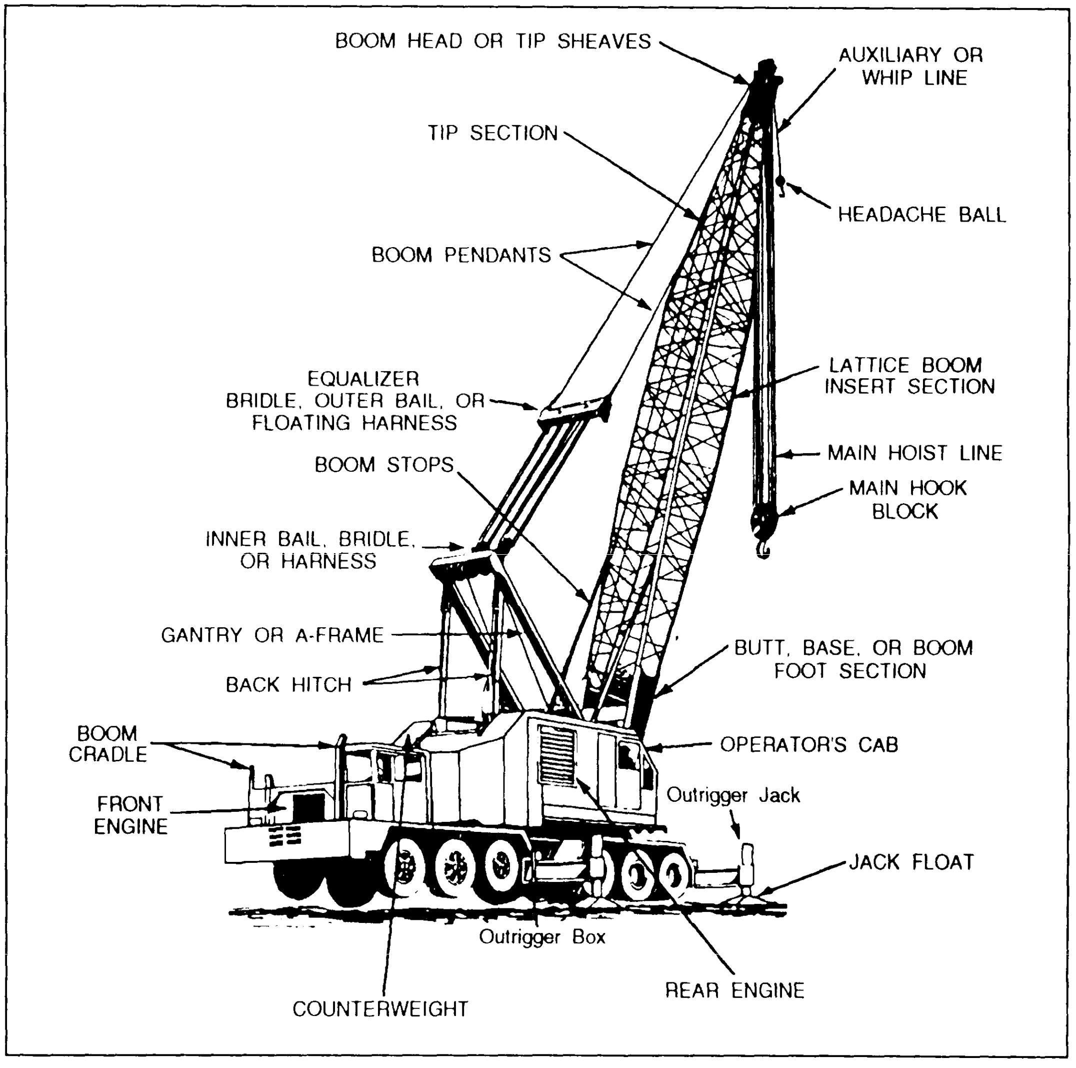
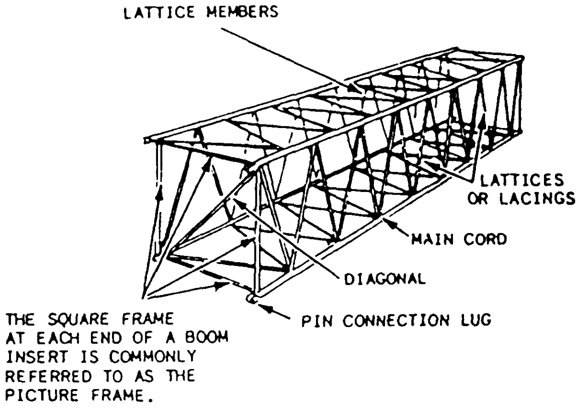


Figure 12-11.—Lattice boom crane components.



33Figure 12-12.-Lattice boom terminology.

removed from service. When the main cords of tubular boom sections are damaged in any manner, including slight dents, they are severely weakened and have failed at loads significantly below capacities. As outlined in the 11200.1, structural repairs will not be made without written approval from COMSECOND/COMTHIRDNCB equipo offices.

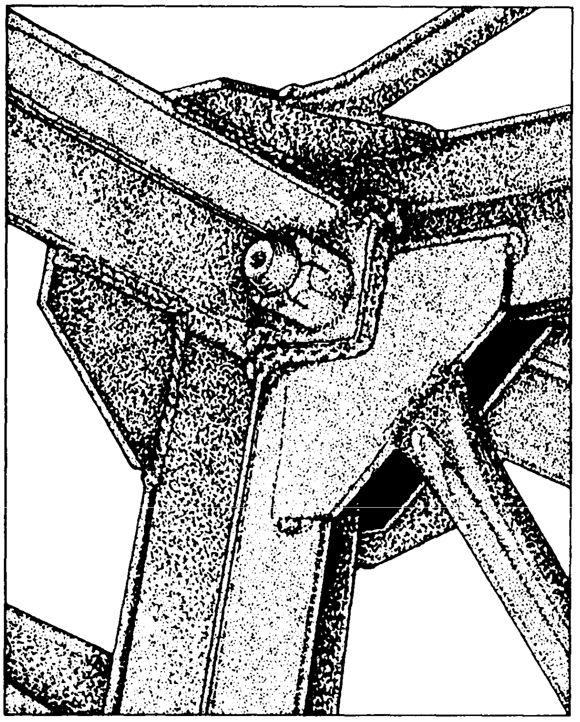
In the NCF, sections normally come in 10- to 20-foot lengths. When adding several sections of different lengths, check the operator's manual for boom section configuration. If this information is not in the operator's manual, a rule of thumb used when mixing short boom sections with long sections, you install the shorter sections closest to the boom butt; for example, if you use two 10-foot sections and one 20-foot section, install the two 10-foot sections closest to the boom butt. The boom sections are bolted by plate (flange) connections (fig. 12-13, view A) or pin and clevis connections (fig. 12-13, view B). The most common is the pin and clevis.

All boom sections that come with a crane will have an attachment identification number attached that assigns the boom section to a specific crane.

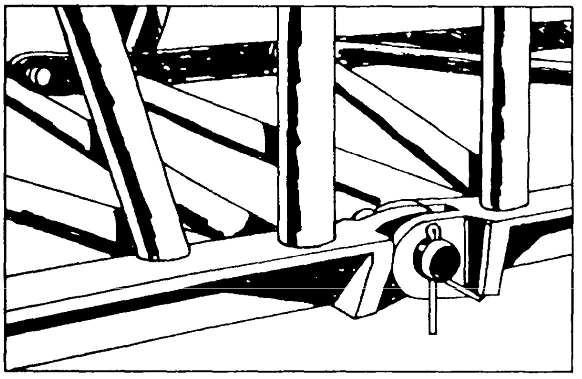
Boom Angle Indicators

Boom angle indicators are normally mounted on the boom butt, visually readable by the operator. On most models in the NCF, the boom angle indicator is a metal plate with degree numbers (0 to 90 degrees) and a freely swinging arm that reacts as the boom angle changes (fig. 12-14). The numbers and arm should remain clean and visually readable at all time.

The capacities that are listed on the crane load charts are also based on and vary with the boom angle of the crane. On hydraulic cranes, the boom angle is the angle between the bottom of the boom butt and the horizontal



VIEW A
BOLT CONNECTION



VIEW B
PIN CONNECTION

Figure 12-13.—Boom sections connection.

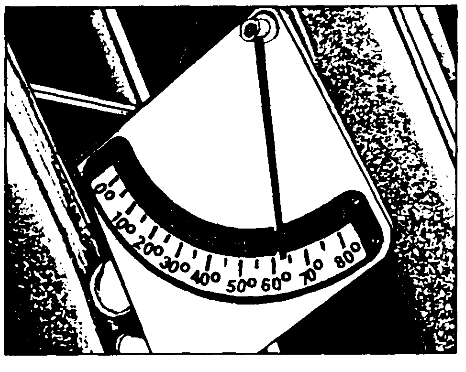


Figure 12-14.—Boom angle indicator.

while the boom is under load (fig. 12-15, view A). The boom angle on lattice boom cranes is the angle between the center line of the boom (from the boom butt pins to the boom tip sheave) and the horizontal while the boom is under load (fig. 12-15, view B).

To check the accuracy of the boom angle indicator, place a 3-foot builders level on the center boom section and raise or lower the boom until the level indicates the boom is level (fig. 12-16). At this point the boom angle indicator

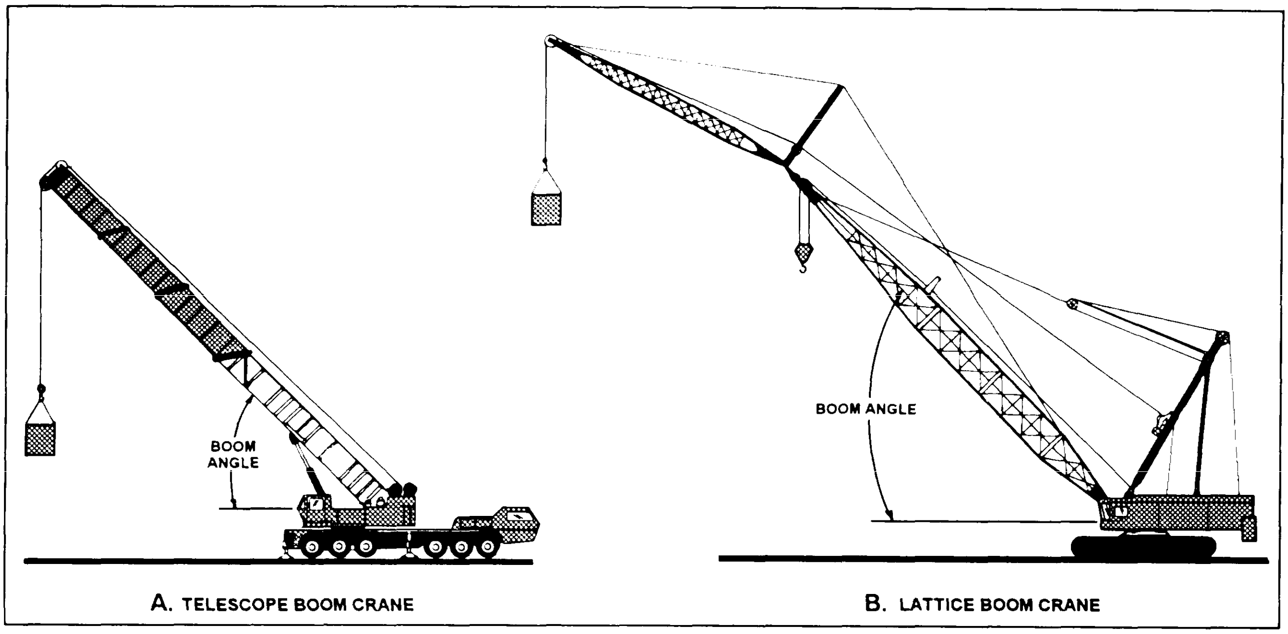


Figure 12-15.—Boom angle configurations.

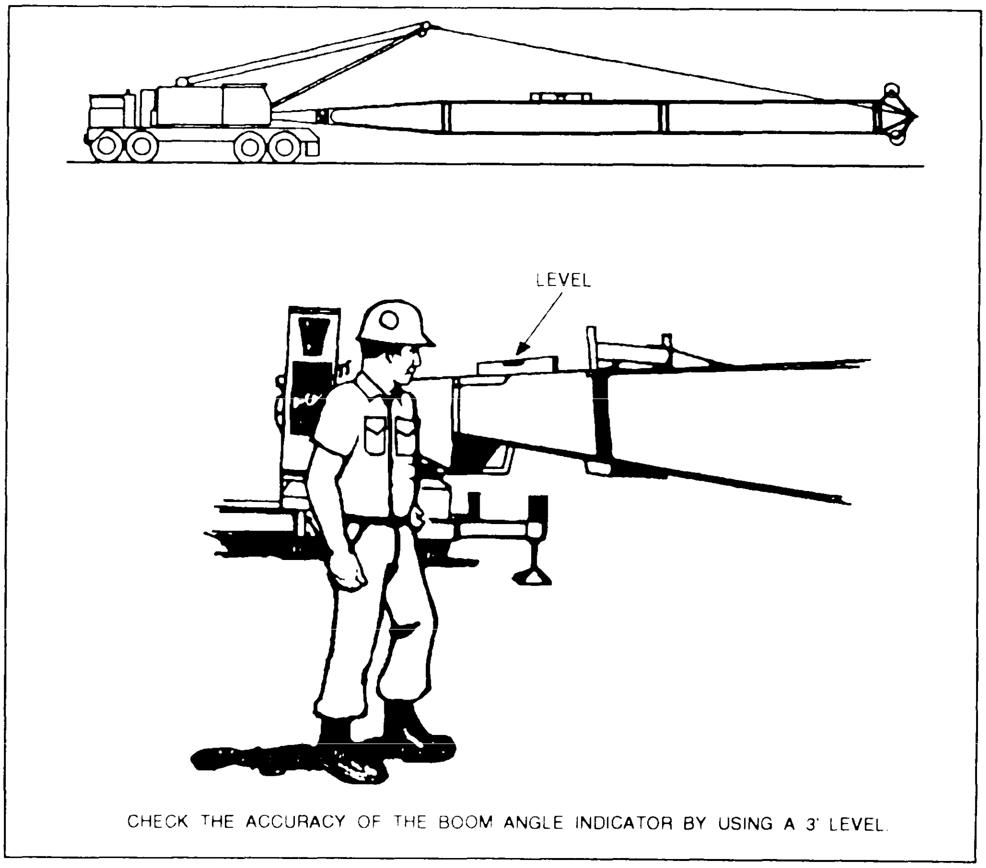


Figure 12-16.-Check accuracy of boom angle indicator.

should show the boom is at zero degrees or adjusted to read zero degrees.

The boom angle indicator is a quick reference for the operator to know what angle the boom is at. However, do NOT rely on the boom angle indicator for radius accuracy especially when the lift exceeds 75 percent of the rated capacity. Use the radius measurement to determine the capacity of the crane from the load charts and to avoid any possibility of error.

Sheaves

Sheaves are located in the hook block boom tip, boom bridle, gantry, and boom mast. Sheaves rotate on either bearings, or bushings, and are installed basically anywhere wire rope must turn or bend.

Boom Pendants

A pendant line is a fixed-length of wire rope, forming part of the boom suspension system. Each section of boom has two boom pendants. Both pendants must stay with the section of the boom they came with. When storing a boom section, secure the two pendants to the boom section with tie wire or rope. If a pendant is bad, both pendants must be replaced. If you only replace the one bad pendant, the new or replaced pendant could be of a different length or be different in manufacture. This difference will cause an uneven pull or twist on the boom when the boom is put under a load or strain.

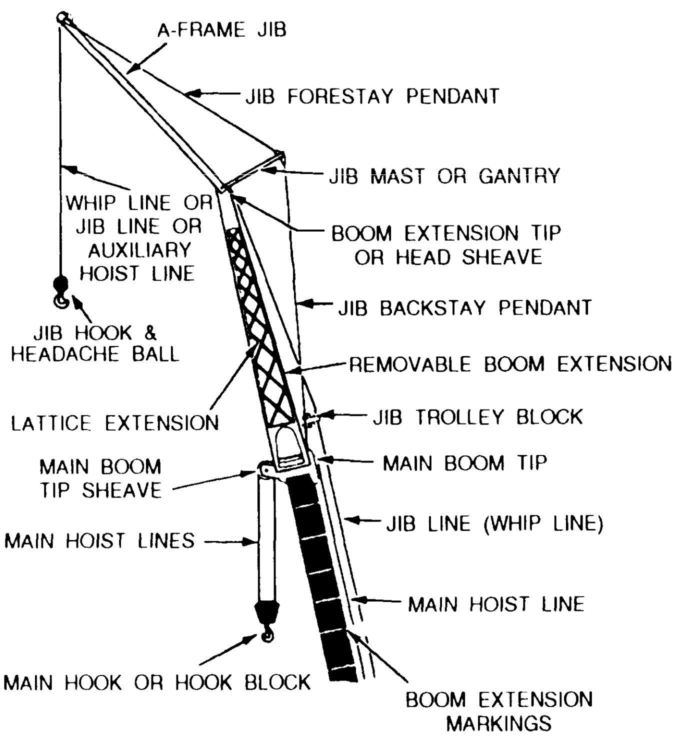


Figure 12-17.—Jib and boom extension mounted on a hydraulic boom.

Jib and Extension

Figure 12-17 shows one type of jib and boom extension. A jib is an extension of a boom capable of being mounted on either a hydraulic or lattice boom. The jib is equipped with its own forestay pendant lines, connected from the jib tip to the jib mast. The jib mast is connected to the boom tip. The jib backstay pendant is normally manually adjustable to change the angle of the jib.

On most cranes the function of the jib is to increase the lift height and to aid in increasing load radius. The operator's manual will have instructions on how to install a jib or extension. You must remember if lifts are made with the main hook block the weight of the jib assembly will reduce the lifting capacity of the crane; therefore, you must deduct the effective weight of the jib assembly from the gross capacity of the crane.

Gantry

The gantry, or A-frame, is a structural frame, extending above the revolving superstructure (fig. 12-18). The gantry supports the sheaves in which the

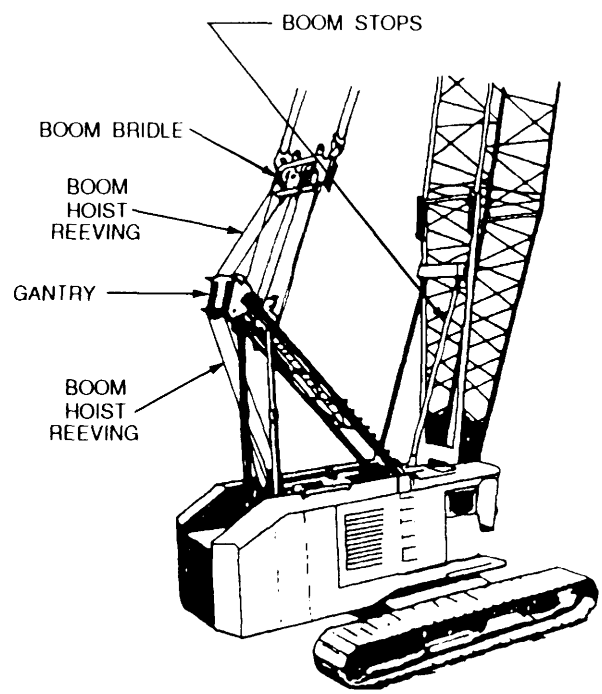


Figure 12-18.-Gantry.

boom hoist lines are reeved. The height of the gantry provides an angle between the boom pendant lines and boom that reduces the compression forces placed on the boom during raising and lifting operations. On some models of cranes, the gantry is adjustable, allowing it to be lowered so the crane can travel under wires and bridges.

WARNING

Refer to the operator's manual for instructions on how to raise and lower the gantry. A trial-and-error method of lowering or raising the gantry can cause serious injury or death.

NOTE: Raising the boom while the gantry is in the lowered position lowers the angle between the pendants lines and boom. This places unseen compression stresses on the boom; therefore, always raise the gantry before raising the boom or lifting a load.

Boom Mast

Some models of cranes are equipped with a boom mast instead of a gantry. The boom mast, sometimes called live **mast,** consists of a structural frame hinged at or near the bottom of the boom butt (fig. 12-19).

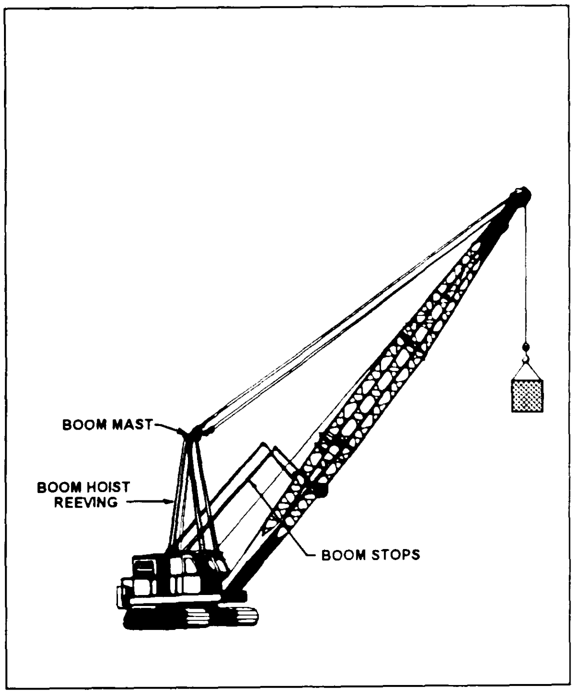


Figure 12-19.—Boom mast.

The tip of the boom mast supports the boom hoist sheaves and boom pendant lines. The boom mast works like the gantry, as it increases the angle between the boom pendants and boom, decreasing the compression forces placed on the boom.

Bridle Assembly

The bridle assembly is part of the boom suspension system and is sometimes called a floating harness. The bridle assembly may be connected to the boom mast or as a floating harness on a crane equipped with a gantry. The bridle assembly is the connection point for the boom pendant lines and is an assembly of sheaves in which the boom hoist wire rope reeves through.

Boom Stops

Boom stops are designed to prevent the boom from going over backwards in case a load line breaks. They will not stop the boom if the operator forgets to disengage the boom hoist control lever. However, some models of cranes are equipped with a boom upper limit switch that prevents the operator from raising the boom past a preset boom angle. This switch also prevents operators from raising the boom into the boom stops. Most cranes that are equipped with the upper limit switch also have a bypass switch that allows the operator to raise the boom past the preset boom angle. Two types of boom stops are shown in figures 12-18 and 12-19.

House Assembly

The house assembly is a revolving superstructure that sets on top of the carrier frame (fig. 12-20). It provides a mount for the hoist mechanisms and engine and is sometimes called the **machinery deck.** The operator's cab and counterweight are attached to the home assembly.

OPERATOR'S CAB.— The control levers for a lattice boom crane are located in the operator's cab. The control levers that are shown in figure 12-21 are typical of most cranes.

Typical crane controls areas follows:

1. The swing lever, when pulled towards you, rotates the house assembly in one direction, and when pushed, the house assembly rotates in the opposite direction.

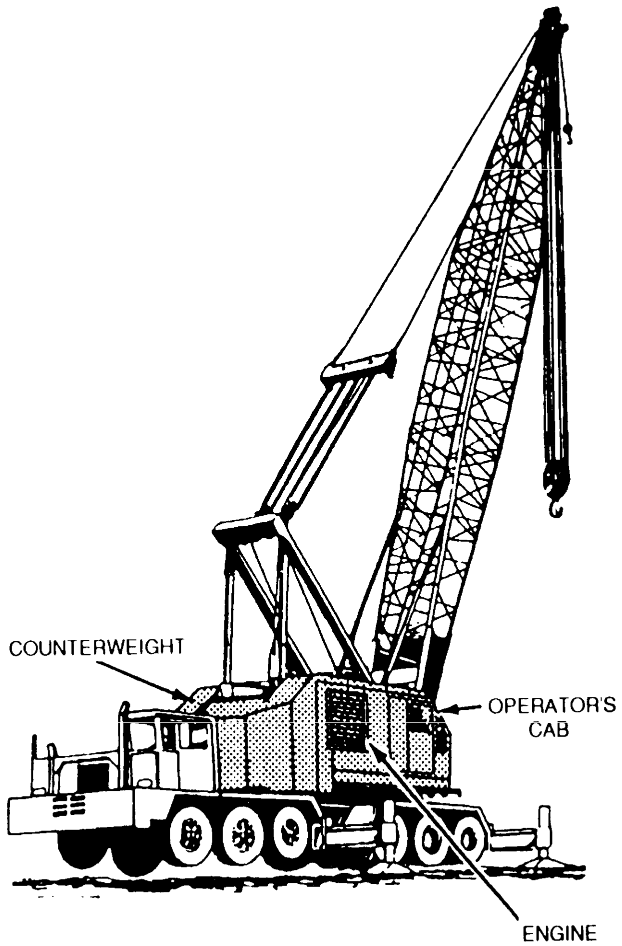


Figure 12-20.—House assembly.

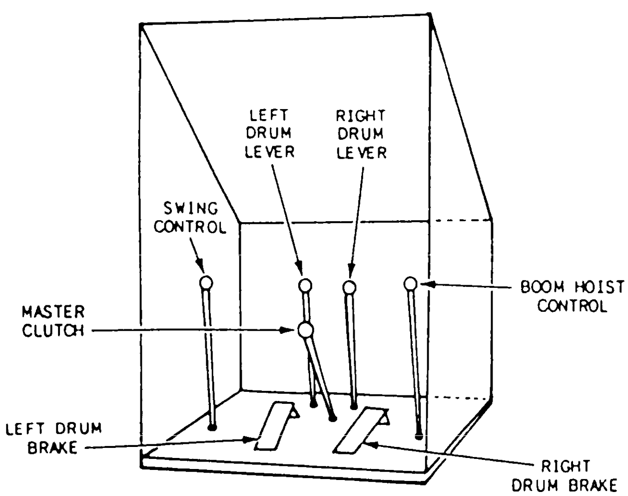


Figure 12-21.—Lattice boom crane control levers.

2. The left drum brake pedal is used to hold and lower loads placed on the hoist line. When locked, it prevents the hook block and wire rope from unwinding on the hoist drum. Figure 12-22 shows a typical hoist brake assembly.

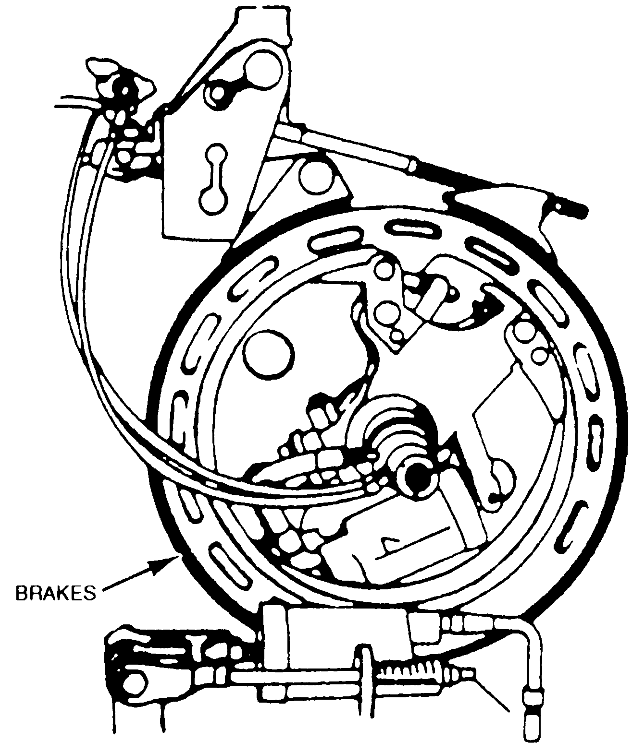


Figure 12-22.—Hoist brake assembly.

3. The main drum lever engages power to raise and, on some models, support lowering of loads placed on the main hoist drum.

4. The master clutch engages the power from the power source to the hoist and swing mechanisms.

5. The secondary drum lever engages power to raise and, on some models, support lowering of loads placed on the secondary hoist drum.

6. The right drum brake pedal is used to hold and lower loads placed on the hoist line. When locked, it prevents the hook block and wire rope from unwinding on the hoist drum.

7. The boom hoist lever allows for the raising and lowering of the boom.

HOISTING MECHANISM.— The hoisting mechanism provides the mechanical power to lift and lower loads. The hoisting mechanism usually has two hoist drums that are mounted side by side on one shaft or in tandem. A separate clutch and brake controls each hoist. The control levers, operating the clutches and brakes, are normally power-assisted with hydraulics or air pressure. A lifting operation requires the use of one drum; whereas the clamshell, dragline, and pile-driving operations require the use of two.

ENGINE.— The engine provides power to the hoisting mechanism through a gearbox or, in some cases, a drive chain reduction. In most lattice boom cranes, the engine is mounted in the crane house.

COUNTERWEIGHT.— The counterweight on the rear of the crane house creates additional stability when lifting loads. The counterweight rotates with the house as it swings. Most counterweights are removable to reduce the overall weight of the crane for transporting. Part of your prestart inspection is to check the counterweight mounting.

Lattice Boom Breakdown

The bridle assembly plays an important part when changing the length of the boom. If you forget to disconnect the boom pendants lines from the boom tip, and not connect the bridle assembly or pendant lines behind the boom section you plan to remove or install, and you drive out the bottom pins, the top pins will act as a hinge and the boom will fall, as shown in figure 12-23. If you make this mistake and a crew member is under the boom, a tragedy could result, as shown in figure 12-24.

WARNING

> **NEVER WORK UNDER A CRANE BOOM.** Because so many accidents have occurred while personnel were changing booms, some manufacturers have made a one-way connecting pin that can only be installed from the inside. This requires the pin to be removed only from the outside, keeping personnel from getting underneath the boom (fig. 12-25). A common practice in the NCF is to install the pins from the inside out to prevent personnel from maneuvering inside the boom to drive out the pins.

Several methods are used to break down lattice booms to add or take out sections. If the boom sections are bolt-connected, you must use dunnage for support under each section.

The most common boom connection is with pins. To break down a pin-connected boom, make sure you

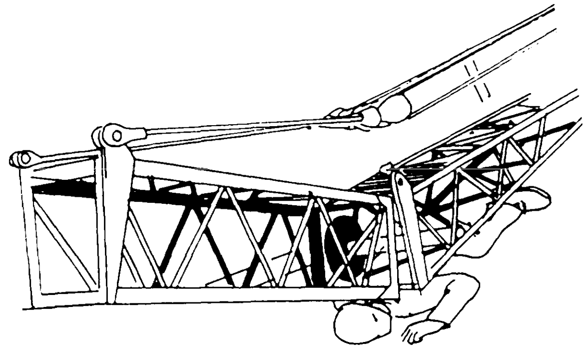


Figure 12-24.-Never work under a crane boom.

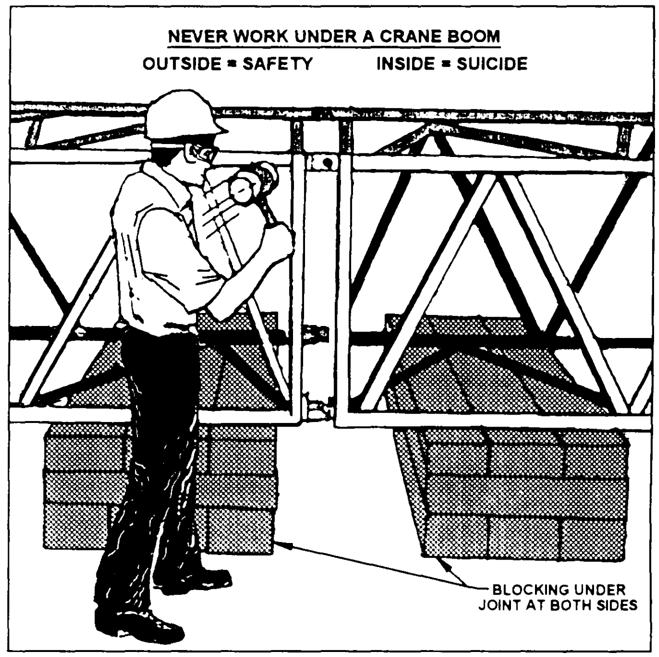


Figure 12-25.-Drive pins from the outside in.

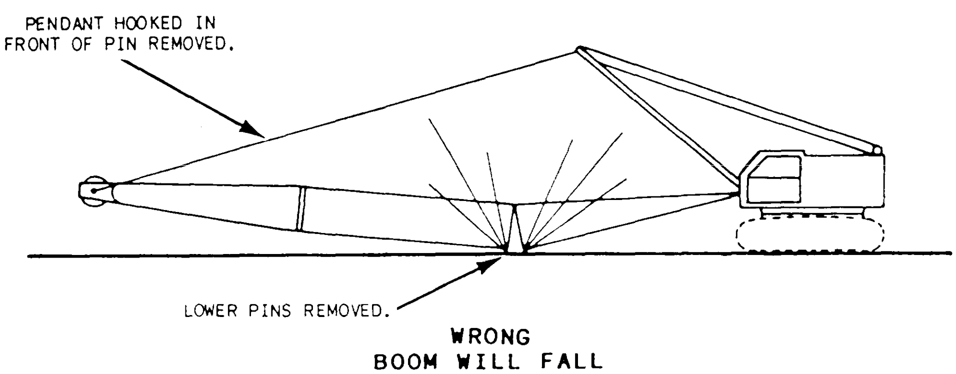


Figure 12-23.—Incorrect way to disconnect the lattice boom.

have gloves, hardhats, safety glasses or goggles, and safety shoes for all hands, sledge hammers, pliers, crowbars, marlin spikes, extra cotter pins, and dunnage.

WARNING

Always wear gloves when handling wire rope.

NOTE: When breaking down a lattice boom, take the opportunity this provides to inspect items thoroughly, such as the connecting pins, cotter keys, and inside the connecting lugs for wear, rust, and surface cracks.

A common method used to break down a pin-connected basic boom and add a section is as follows:

1. Set outriggers and swing the upper revolving unit over the rear or side, depending on the make and model of the crane.

2. Lower the hook block(s) to the ground and provide slack in the hoist line(s). Next, lower the boom and set the boom tip sheaves on a piece of dunnage.

3. Engage the boom hoist control lever to lower the bridle assembly or boom mast to slacken the pendant lines.

4. To prevent the pendant lines from falling on the ground, use tie wire or rope to secure the pendant lines to the boom. Then remove the cotter pins and drive out the main pins from the bridle assembly connections in the pendant lines.

5. Position the bridle assembly on top of the boom butt (fig. 12-26, view A). This is done by having the operator engage the boom hoist control lever to tighten the boom hoist lines until the bridle is positioned on top of the boom butt. To align the pinholes, manually position the bridle assembly using the crowbar. The pins that are used for the pendant line connections are

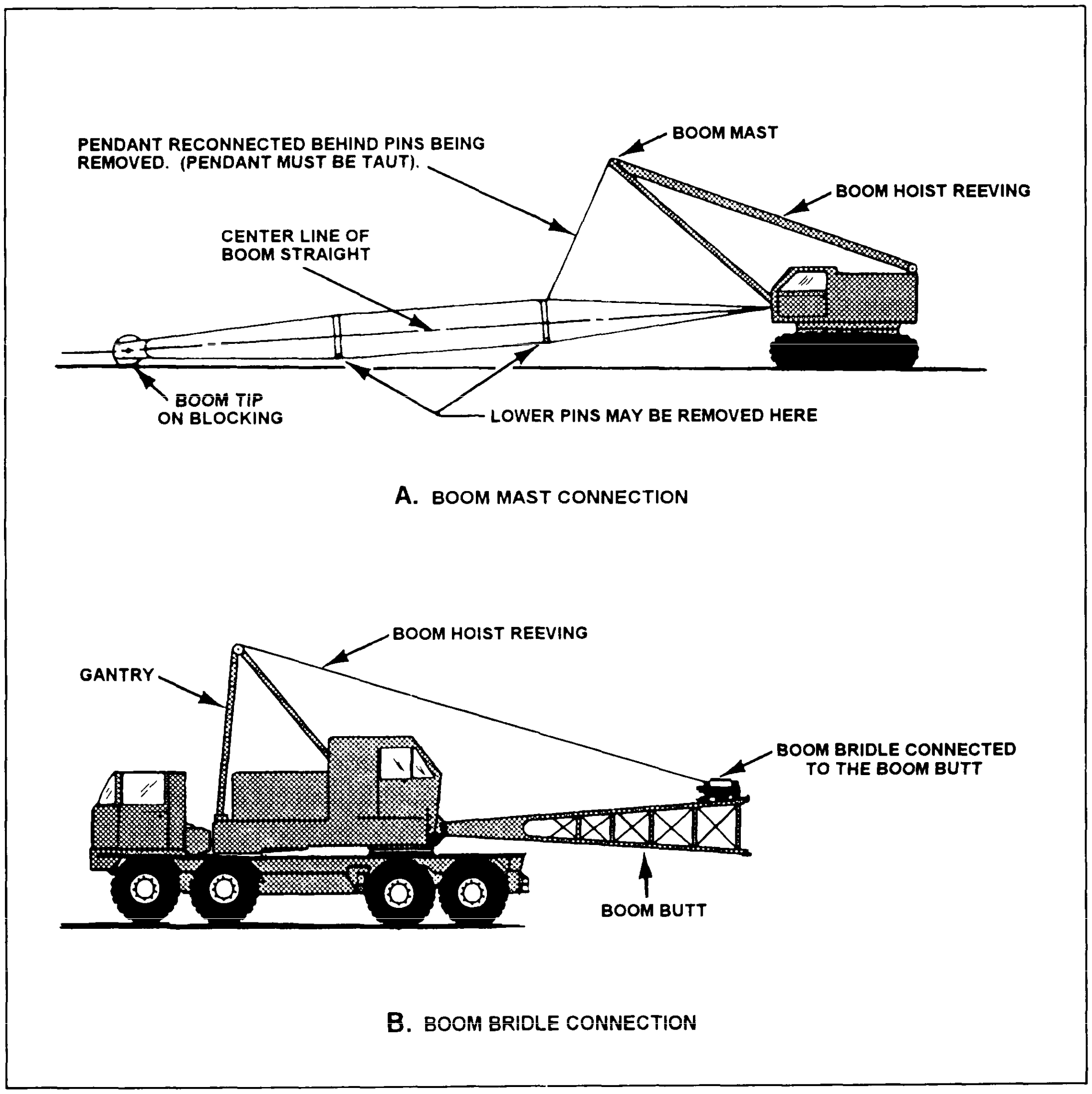


Figure 12-26.-Boom hoist assembly connected to boom butt.

normally the pins used to connect the bridle assembly to the boom butt. If the crane is equipped with a boom mast, the boom mast normally has a short set of pendants that connect to the boom butt pinholes (fig. 12-26, view B).

NOTE: Visually check the boom hoist drum to ensure the boom hoist wire rope does not loosen and cross wind on the hoist drum, resulting in crushing or kinking the wire rope.

6. Tighten the boom hoist lines to support the weight of the boom, but not so tight that the boom tip is lifted off the dunnage.

7. Remove the cotter pins from the boom connection pins and drive out the lower boom connection pins.

8. After the lower pins are removed, engage the boom hoist control lever and lower the bridle assembly or mast, allowing the boom to separate at the bottom by hinging on the top pins. hen lower the boom on a piece of dunnage.

9. Remove the top connecting pins. Once removed, engage the boom hoist enough to separate the boom connections lugs.

When the boom breakdown is performed over the rear of the crane, you separate the boom by (1) raising the outriggers enough to move forward with the travel unit and by (2) releasing the brakes on the hoist line(s) to slacken the hoist wire rope, as the travel unit moves forward to allow space to add a section(s).

When the boom breakdown is performed over the side of the crane, you separate the boom by (1) releasing the brakes on the hoist line(s) to slacken the hoist wire rope and by (2) using a forklift to pick up the boom tip carefully and maneuver it enough to provide adequate space to insert a boom section(s).

A method for adding a boom section is as follows:

1. Have a forklift align the boom section with the boom butt.

2. Reverse the crane until the boom butt top pin connection lugs are connected with the top pin connection lugs on the boom section. The boom breakdown performed over the side requires a forklift to maneuver the boom section until the pins are aligned.

3. Once the top lugs are aligned, drive the boom connection pins into the top lugs from the inside out and insert the cotter pins.

4. Engage the boom hoist control lever to raise the boom butt. This allows the top pins to perform as a hinge that draws the bottom pin connection lugs together.

5. Once the bottom lugs are aligned, drive the boom connection pins into the bottom lugs from the inside out and insert the cotter pins.

6. Raise the boom butt and boom section several inches to clear the ground. Reverse the crane until the top connection lugs of the boom section align with the top connection lugs of the boom tip. Final alignment of the lugs might require the use of a crowbar.

7. Once the lugs are aligned, drive the boom connection pins into the top lugs and insert the cotter pins.

8. Engage the boom hoist control lever to raise the boom section and boom tip. This results with the top pins performing as a hinge, drawing the bottom pin connection lugs together.

9. Once the bottom lugs are aligned, drive the boom connection pins into the bottom lugs from the inside out and insert the cotter pins.

10. Reset the outriggers.

The procedures for connecting the bridle assembly to the boom pendants are as follows:

1. Engage the boom hoist control lever to lower the bridle assembly or boom mast to produce slack in the boom hoist wire rope.

2. The next step is to connect the boom bridle assembly to the boom section pendant lines. This is done by disconnecting the bridle assembly from the boom butt and manually maneuvering the bridle assembly to connect with the boom pendants of the boom section. To produce slack in the bridle assembly may require manually feeding of the boom hoist wire rope through the sheaves.

For cranes equipped with a boom mast, lower the boom mast to connect the pendant lines.

3. When the pendants are connected to the bridle, it is a good practice to insert the pins from the inside out. This practice allows for a easier visual inspection of the cotter pins inserted in the pendant line pins when the boom is in the air.

4. The next step is to connect the boom section pendants to the boom tip pendants. This usually requires manual labor to align the boom section pendants to the boom tip pendants. You may also have to engage the boom

hoist control lever to provide slack in the boom hoist lines to align the pendant lines. Once the pendants are aligned, insert the pendant connection pins and cotter pins.

5. Next, engage the boom hoist control lever to raise the bridle assembly and pendants. Before doing this, go back through and visually inspect all boom and pendant line pin connections and cotter pins. Have someone visually watch the boom hoist drum to ensure the wire rope does not cross wind, causing the wire rope to be crushed or kinked. Additionally, ensure all of the boom hoist wire rope is properly running on all of the sheaves. Once everything checks out, engage the boom hoist control lever and raise the bridle assembly and pendants until they are tight.

6. Visually check the boom suspension system before raising the boom off the ground As the boom is being raised, visually check the reeving of the boom hoist wire rope.

7. Once the boom is erected, check the hoist wire rope reeving. You want to ensure the wire rope is correctly flowing through the boom tip and hook block sheaves and winding properly on the hoist drum.

Before the crane can be operated, as outlined in the *NMCB, Equipment Management,* COMSECOND/COMTHIRDNCBINST 11200.1, and before putting the crane back in service, the crane test director must inspect the crane for correct installation of all components and verify the prior testing and mechanical condition of added components. The crane certifying officer may direct the crane to be load-tested at its safe load capacity at minimum and maximum radius.

TELESCOPIC BOOM CRANES

Telescopic boom cranes are typically called hydraulic cranes. The booms are composed of a series of rectangular, trapezoidal, or other shape of symmetrically cross-sectional segments, fitting into each other. The largest segment, at the bottom of the boom, is called the **base section** or **boom butt.** The smallest section, at the top of the boom, is called the tip section or boom tip. In between there can be one or more sections called the **first, second, and so forth, sections.** With the boom fully retracted, the telescopic boom crane is highly maneuverable and easy to transport to jobsites. Telescopic boom crane nomenclature is shown in figure 12-27.

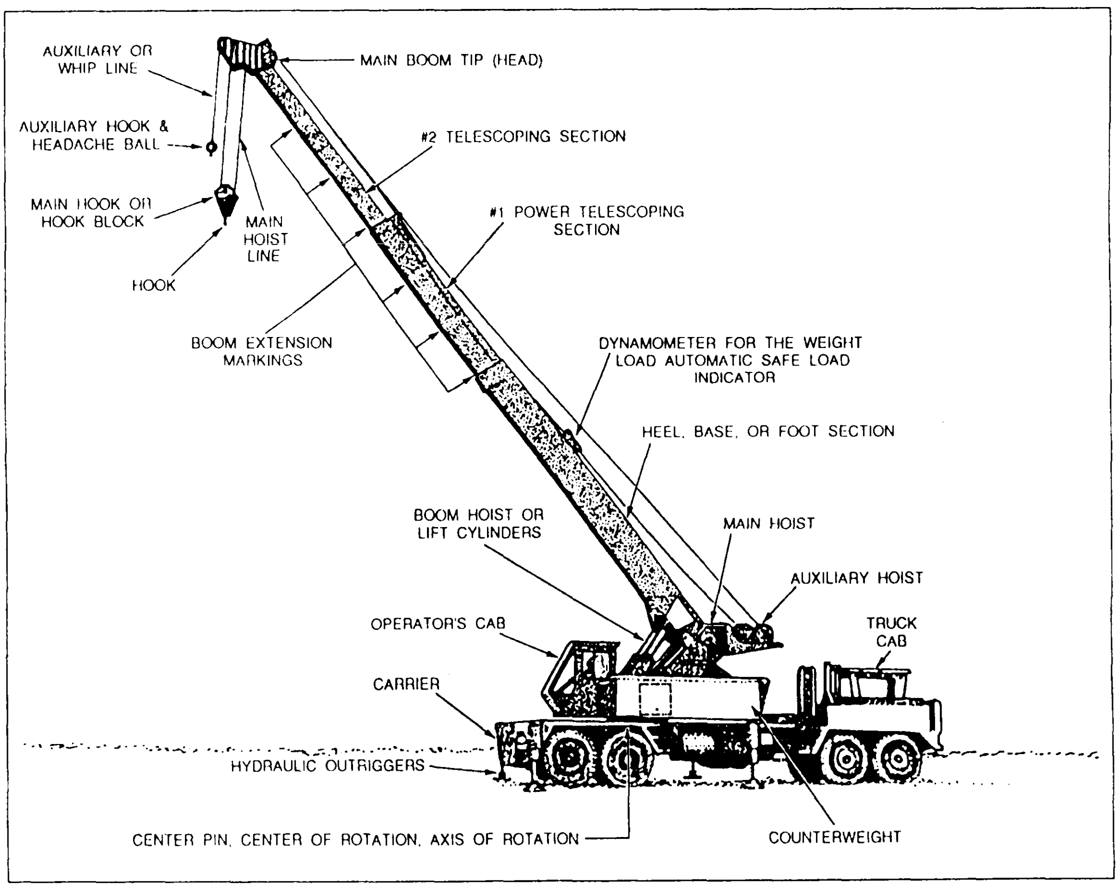


Figure 12-27.—Telescopic boom crane nomenclature.

Sections

Telescopic booms may be **a pinned boom, full-powered boom,** or a combination of both. A "pinned boom" means sections are pinned in the extended or retracted position. A "full-powered boom" means sections extend or retract hydraulically. Some models have a full-powered main boom with a pinned boom tip section. Read the operator's manual for the proper operation of the type of boom that is equipped on the crane you are assigned to operate.

On a full-powered boom, the sections are extended and retracted (except for the base section) by hydraulic cylinders, called extension cylinders. The cylinders are mounted parallel to the boom center line within each section. The boom extension cylinders on most telescopic booms have sequencing valves that allow the sections to extend (telescope) by equal amounts. These cranes usually have a single telescope control lever in the cab. However, on cranes not equipped with sequencing valves, the operator will have to extend each section equally. (The crane will have two or three boom telescope control levers in the cab, each controlling only a single boom section.) If the boom sections are extended unequally, the most fully extended section of boom could bend to uneven stresses. Additionally, the load chart will be invalidated for determining rated capacity of the crane. Boom sections that are marked off in equal increments, as shown on the boom in figure 12-27, make it easier for the operator or signalman to make sure each section is extended equally.

When a load is placed on a telescopic boom, the load weight on the boom causes the hydraulic rams within the boom to stiffen up and slightly curve. As the load is removed from the boom, the rams return straight. Because of this, do not extend the boom while it is under load. Read the operator's manual for boom extension information.

Hoisting Mechanism

The hoisting mechanism for a telescopic crane is a hydraulically powered hoist drum. The hoist drum is mounted behind the boom on the crane house or revolving turntable. Some hydraulic cranes are equipped with two hoist drums: one for the main hoist and the second for the auxiliary or whip line.

House Assembly

The house assembly is a revolving unit that supports the boom. Some small hydraulic cranes have the operator's cab and counterweight attached to the revolving unit.

OPERATOR'S CAB.— The telescopic crane will have hoist, swing, and boom control levers similar to the cab of the lattice boom crane. Control lever(s) is/are also provided to extend and retract the boom. The hoist system does not require foot-controlled brakes. When the hoist control lever is returned to the neutral position, the hydraulic system holds the load in place.

POWER SOURCE.— The power for a telescopic crane comes from hydraulic fluid. In most cases, the main carrier engine drives the hydraulic pump that supplies the hydraulic fluid to hydraulically controlled components. Power is diverted to hydraulic motors or cylinders by the valve body at the operator's control station. The hydraulic power provides positive control of all crane functions.

COUNTERWEIGHT.— The counterweight on a telescopic crane provides greater stability when lifting loads. When you are performing near-capacity lifts at high boom angles using a telescopic crane, about 60 percent of load weight is placed on the outriggers away from the load. When you are performing the same lift with a lattice boom crane, about 60 percent of the load is placed on outriggers close to the load.

CRANE ATTACHMENTS

The crane is a versatile piece of equipment that can be equipped with various attachments to perform a number of different operations. These attachments include a hook block, a clamshell, and a dragline.

HOOK BLOCK

A crane that is rigged with a hook block is the primary unit for lifting an objector load, transferring it to a new place by swinging or traveling and then placing the load. Figure 12-28 shows an eight-part line rigged hook block.

The number of parts of a line rigged on the hook block is important for figuring the capacity of the crane. Most crane load charts show the rated capacity of the crane for different parts of the line; for example, a crane that is capable of being rigged with a eight-part line is rigged with a six-part line. The eight-part line gives the crane a greater lifting capacity; therefore, you must check the load chart for the six-part line capacity to avoid overloading the crane.

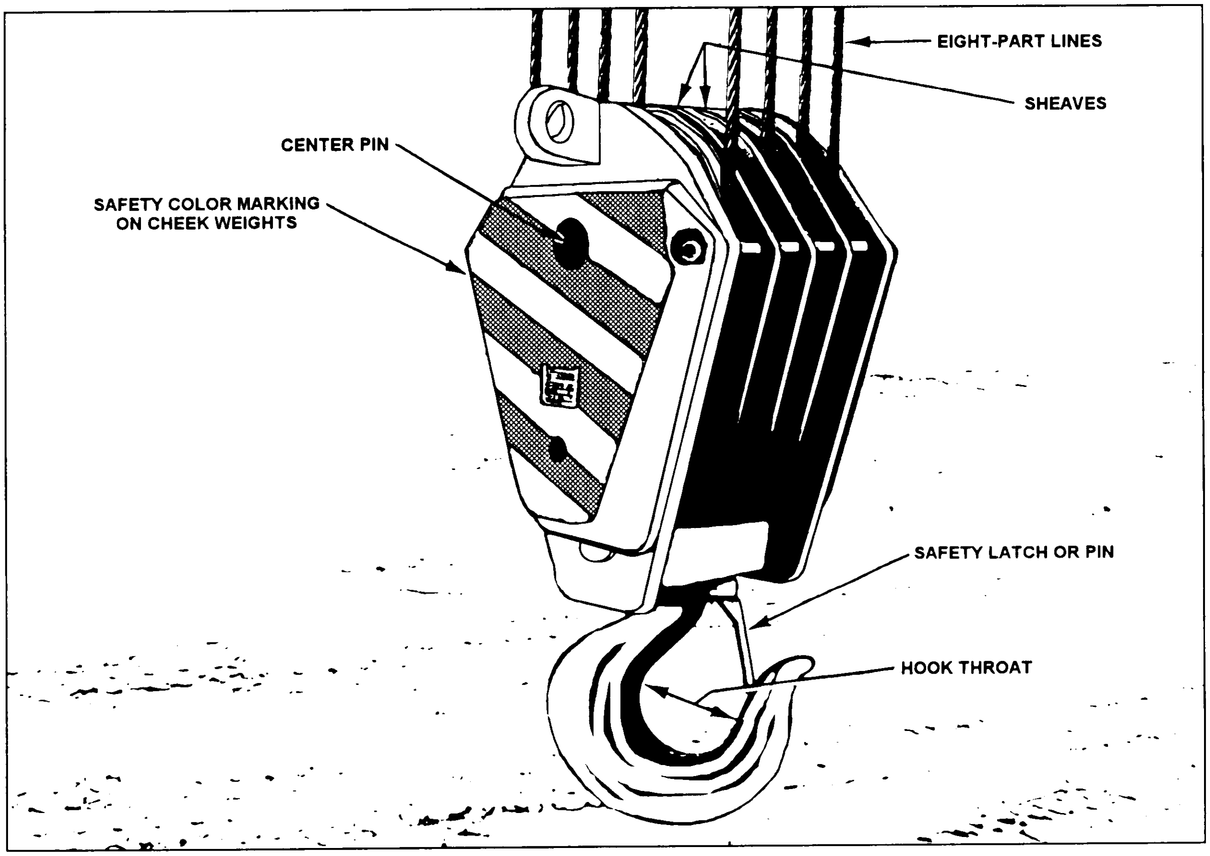


Figure 12-28.-Hook block.

CLAMSHELL

A clamshell consists of hoist drum lagging, clamshell bucket, tag line, and wire ropes to operate holding and closing lines. On some crane models, the hoist drum lagging (hoist drum diameter) can be changed to meet the speed or pull requirements for clamshell operations. Once a crane is rigged with a clamshell, the crane is referred to by the name of the attachment.

When changing attachments from a hook block to a clamshell, check the operator's manual for the correct length of wire rope reeving; for example, some crane models require 300 to 400 feet of wire rope for hook block operations and only 100 to 200 feet of wire rope for clamshell operations. Too much wire rope on the hoist drum during clamshell operations will cause the wraps of wire rope to loosen on the hoist drum and cross wind, resulting in crushed wires and kink spots in the wire rope. This is very expensive, because the wire rope is usually no longer useful for hook block operations.

Changing the length of rope requires unreeving the hook block wire rope and reeving the correct length of wire rope for the clamshell. This may be a time-consuming effort, but saves you from having to replace 300 to 400 feet of wire rope when the crane is rigged for hook block operations.

The clamshell bucket (fig. 12-29) is two scoops hinged together in the center with counterweights

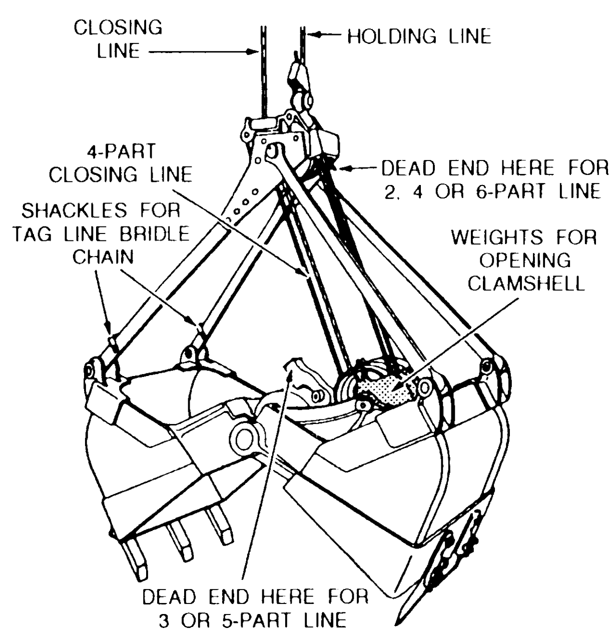


Figure 12-29.-Clamshell bucket.

bolted around the hinge. The two hoist drum wire ropes on the crane are rigged as the holding and closing lines for controlling of the bucket. An example of a clamshell rigging configuration is shown in figure 12-30.

The tag line winder (fig. 12-31) controls the tension on the tag line that helps prevent the clamshell from twisting during operations. Like the clamshell bucket, the tag line winder will exchange with most makes or models of cranes in the same-size range.

DRAGLINE

The dragline component (fig. 12-32) consists of a dragline bucket and fairlead assembly. The wire rope components of the dragline are the drag cable, the bucket hoist, and the dump. Once a crane is rigged with a dragline, the crane is referred to by the name of the attachment,

When you are loading the bucket, the fairlead (fig. 12-33) guides the drag cable onto the hoist drum. The hoist wire rope, which is reeved through the boom point sheaves, raises and lowers the bucket.

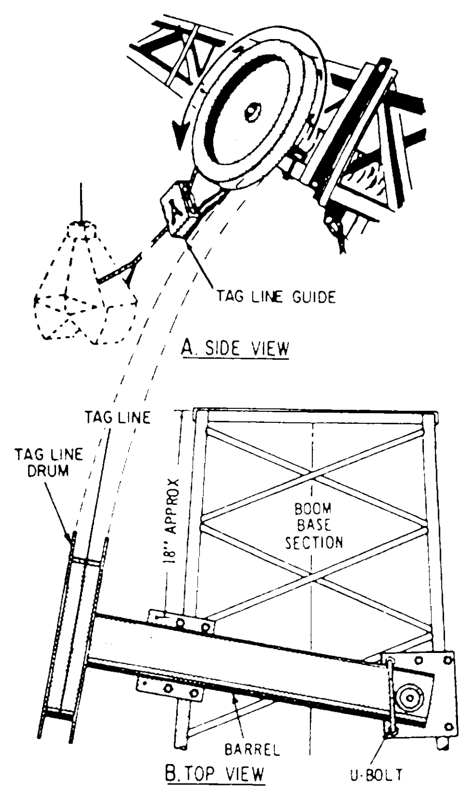


Figure 12-31.—Tag line winder.

WARNING

On some model of cranes, you must make sure the fairlead is in a vertical position when lowering the boom to avoid bending the cords of the boom base.

When changing attachments from hook block or clamshell to dragline, check the operator's manual for the lengths and diameter size of wire rope required for dragline operations. The pulling force of the dragline

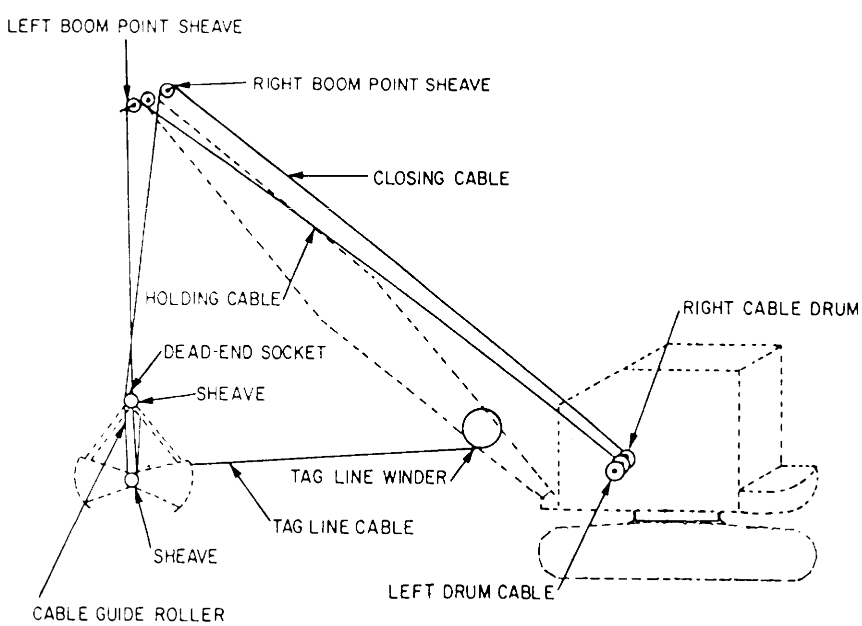


Figure 12-30.-Clamshell rigging configuration.

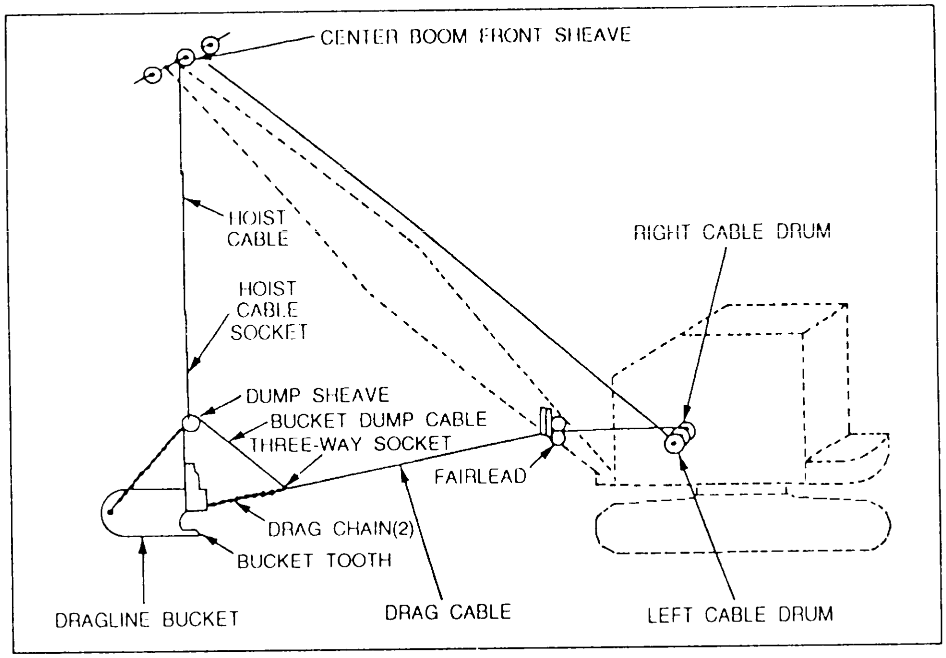


Figure 12-32.-Dragline.

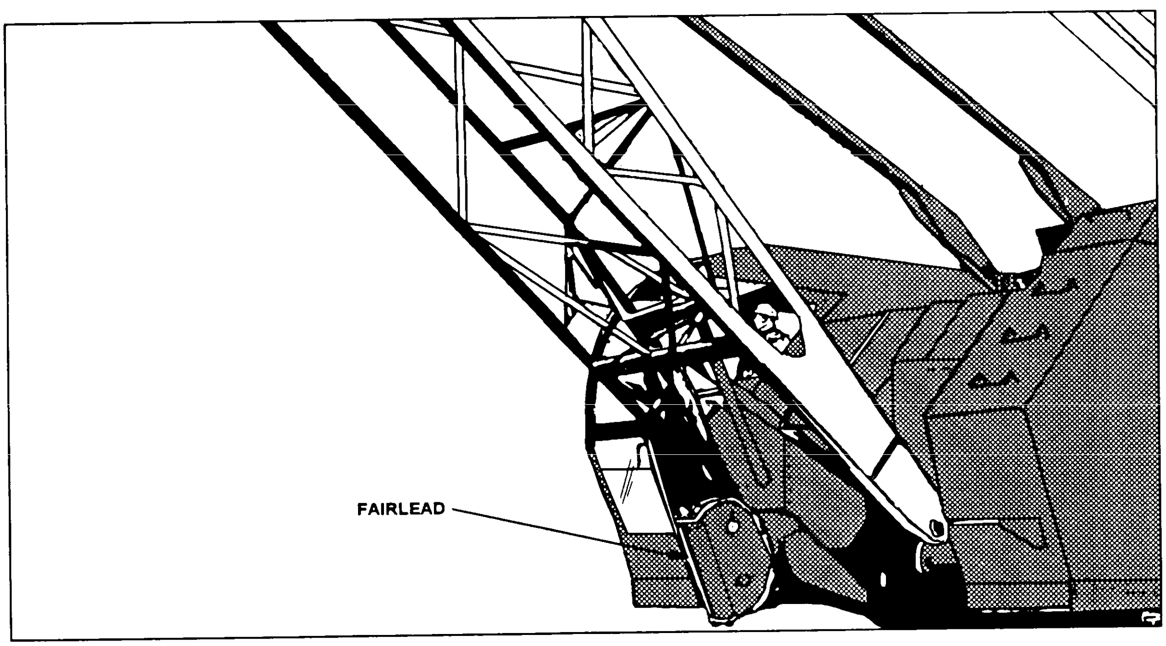


Figure 12-33.—Dragline fairlead.

normally requires a larger diameter drag cable. The length of the hoist wire rope is also shorter than normal to avoid cross winding on the hoist drum. The drag cable pulls the bucket through the material when digging. When the bucket is raised by the hoist wire rope and moved to the dump point, dump the bucket by releasing the tension on the drag cable.

NOTE: Do not lubricate the drag cable. If the drag cable is lubricated and pulled through the dirt, it retains the dirt, which causes damage to the wire rope.

The construction industry rates dragline buckets in different types and classes. The types and classes are as follows:

- Type I (light duty)
- Type II (medium duty)
- Type III (heavy duty)
- Class P (perforated plate)
- Class S (solid plate)

The most common buckets used by the Navy are the type II, class S buckets. Class P buckets are available for dredging operations. Figure 12-34 shows the makeup of a drag bucket.

CRANE OPERATIONS

People are crippled or killed and enormous property damage is incurred as a direct result of crane mishaps. Most of these crane mishaps result from **OPERATOR ERROR.** The Naval Construction Force (NCF) has an extensive crane safety program that applies to crane operators and the safe operation of weight-handling equipment.

Standards for weight-handling equipment operations are outlined in the *Management of Weight-Handling Equipment,* NAVFAC P-307; *NCF Equipment Management Manual,* NAVFAC P-404; *NMCB Equipment Management,* COMSECOND/COMTHIRDNCBINST 11200.1; *Use of Wire Rope Slings and Rigging Hardware in the NCF,* COMSECOND/COMTHIRDNCBINST 11200.11; and *Testing and Licensing of Construction Equipment Operators,* NAVFAC P-306.

CRANE CREW

The skills and safety standards demanded for efficient crane operations require only mature professionals be assigned as crane operators and riggers. The supervisor of the crane crew is normally the best crane operator available within the battalion-wide assets and is assigned and designated in writing by the commanding officer. The equipment officer, the crane test director, and the crane crew supervisor share the responsibility of ensuring that any personnel that prepares, assembles, operates, or works with or around cranes are well trained in both safety and operating procedures.

Before you receive a license to operate a crane, crane operators are required to attend 40 hours of formal classroom instruction on crane operating safety, as outlined in NAVFAC P-306. Additionally, operators who need to renew their license must attend a minimum

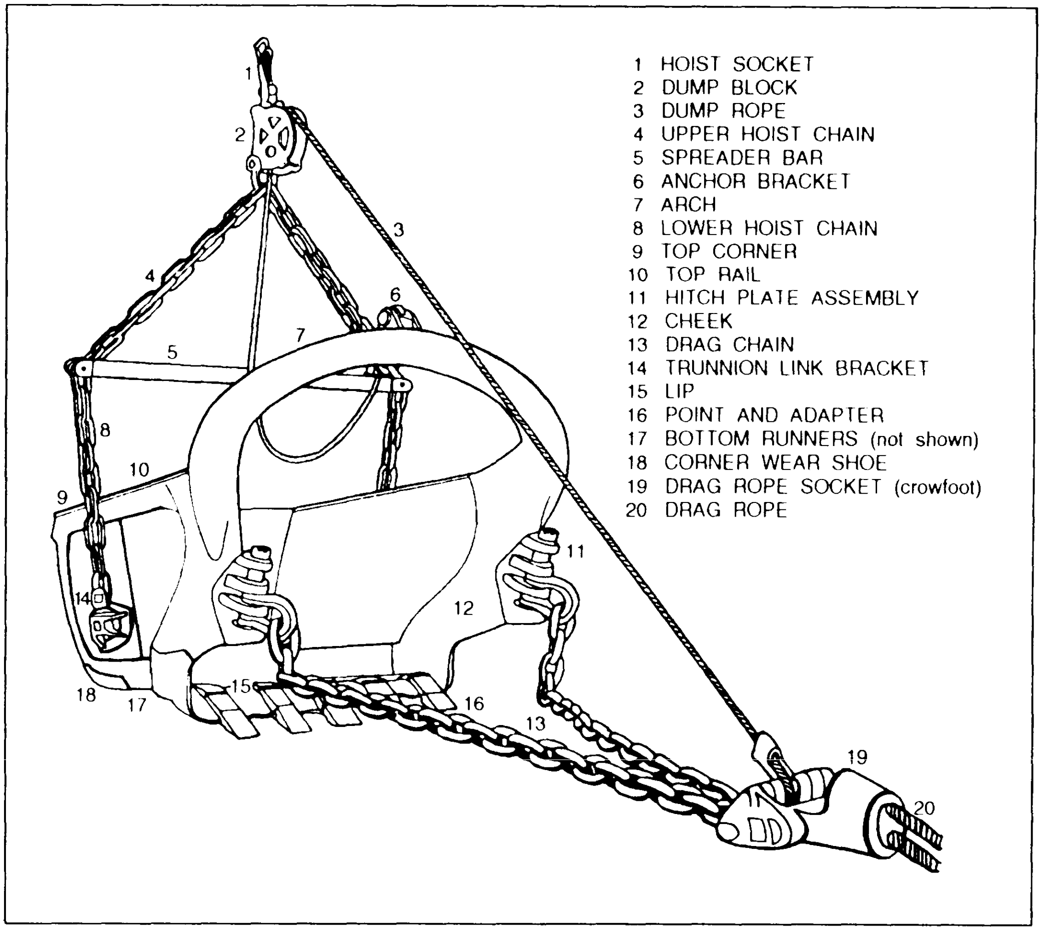


Figure 12-34.-Dragline bucket.

8-hour refresher training course on crane operator safety.

The testing of crane operators is the direct responsibility of the crane certifying officer. The crane certifying officer may be assisted in administering a performance test by the crane test director. The equipment officer is normally responsible for the duties of the crane certifying officer and is designated in writing by the commanding officer. The crane certifying officer designates in writing the crane test director and all crane test personnel. Crane license is issued on the Construction Equipment Operator License, NAVFAC 11260/2, and will indicate the make, model, capacity, and the attachments the operator is qualified to operate.

Signalman

The signalman is part of the crane crew and is responsible to the operator to give signals for lifting, swinging, and lowering loads. A signalman should be a qualified seasoned crane operator. Not only does the signalman give signals for handling loads but the signalman can visually observe what the operator cannot see from the operator's cab. For example, during a lift the signalman should make a visual check of the following:

1. The load hook is centered over the center of balance of the load, as the weight is being lifted by the crane.

2. The boom deflection does not exceed the safe load radius.

3. All the rigging gear is straight and not causing damage to itself or the load.

4. During a lift with a lattice boom crane, check the boom suspension system and boom hoist reeving to ensure proper operation.

5. Check the hook block and boom tip sheaves reeving to ensure proper operation.

6. Check the stability of the outriggers especially when swinging from one quadrant of operation to another.

NOTE: On some cranes, the capacity of the crane changes when swinging from the rear quadrant to over-the-side quadrant.

7. Use tag lines and tag line handlers to prevent the load from swinging or twisting.

WARNING

Allowing personnel to control a load by the use of hands puts them in great danger should the load fall or some unexpted mishap occurs.

8. Signal only to lift the load high enough to clear any obstacles.

9. ALWAYS have eye-to-eye contact with the crane operator. The crane operator depends on the signalman to lift, swing, and lower a load safely.

The signalman must also know the load weight being lifted and the radius and capacity of the crane. The basic hand signals used throughout the NCF are in appendix IV of this TRAMAN. Only one person gives signals to the operator. The only time anyone else should give a signal is for an **EMERGENCY STOP.**

Rigger

The rigger or riggers are responsible to the operator for properly attaching the rigging gear to the load. Rigging can be an extremely dangerous job if not properly performed. Safety gear, such as hard hats, steel-toed shoes, gloves, and any other personal safety clothing needed, must be worn.

Riggers and signalman must work closely together after the load is rigged. The signalman visually checks for proper rigging that the operator cannot visually see from the operator's cab. Once the rigging is approved, then the load can be signaled to be lifted.

NOTE: The operator has the final approval on any lift and has the ultimate responsibility for the crane lift and safety.

Operator

The operator pulls the levers on the crane and is directly responsible for the crane, the load rigging, and the lifts performed. You must know the crane, how to operate it, how it responds under loaded and unloaded conditions, proper rigging procedures, and signaling. You must be able to set the crane up properly for lifts, always keeping in mind that safety comes first and production second.

CRANE OPERATOR'S DAILY INSPECTION

Before a crane is operated or transported, it must be thoroughly inspected by the operator. The operator uses the Crane Operator's Daily Checklist (ODCL) (fig. 12-35). The operator visually inspects and checks each item prescribed on the checklist.

When the operator observes a deficiency of a **load-bearing** or **load-controlling** part or safety device (major deficiency) or an operating condition that would cause the slightest loss of control or otherwise render

Crane No.	Type	Location or Assignment	Shift 1 2 3	Date

Hour Meter Readings Beginning	Ending	Hrs Operated This Shift	Operator (Name) Oiler (Name)
			Legend: "S" Satisfactory, "U" Unsatisfactory

Item	S	U	Item	S	U	Item	S	U
Engines-Oil Levels			Walkways, Ladders, Handrails			Radiator Coolant		
Fan Belts			Glass			Tanks (Oil-Air)		
Fuel Oil (Amount)			Hooks			Air Compressor		
Gauges & Indicator Lights			Housekeeping			Battery-Water		
Wire Rope & Reeving			Lubrication			Tires & Wheels		
Limit Switches			Wind Locks & Chocks & Stops					
Brakes			Controllers					
Leaks (Fuel-Oil-Water)			Motors					
Warning Devices			Lights					
Instructions: See reverse side						Fuel Gals	Oil Qts. Gal	

CRANE OPERATOR'S DAILY CHECKLIST

(FRONT)

Instructions		
Check all items daily. Suspend operations immediately if an unsatisfactory item effects safety for continued operations and report all such conditions immediately to the supervisor-in-charge.	Report unsatisfactory items not effecting safe operations to the supervisor-in-charge at the end of the work shift.	
Remarks (Unsatisfactory Items)		
Operator Signature	Operations Supervisor Signature	Date
Remarks:		Supplies (Check if required)
Maintenance Supervisor Signature	Date	

(BACK)

Figure 12-35.—Crane Operator's Daily Checklist.

the crane unsafe, the operator must secure the crane and notify the crane crew supervisor.

The Operator's Daily PM Report, NAVFAC Form 11260/4, is also used with the ODCL when performing the crane prestart inspection. The ODCL is turned in to the crane crew supervisor at the end of each day or shift for reviewing and signing. The NAVFAC Form 11260/4 is turned in to dispatch. As outlined in the NAVFAC P-307, the minimum requirement for retaining ODCLs is those completed during the current month and during the previous month of operation.

Wire Rope Inspection

Part of the ODCL inspection is the thorough inspection of all wire rope before using a crane. All running rope in continuous service must be visually inspected for crushing, kinking, corrosion or other damage, broken wires, and proper lubrication (fig. 12-36).

Other areas to inspect are wire rope sockets, swage fittings, swivels, pendants, and securing hardware for wear. Hoist drum end fittings need only be disconnected or disassembled when experience or visible indications deem it necessary.

The exact time for replacement of wire rope cannot be given because many variables are involved; however, safety depends upon the use of good judgment in evaluating wire rope.

The following conditions are reasons for wire rope replacement:

1. Running ropes. six or more broken wires randomly distributed, broken or torn wires in one lay, or three broken wires in one strand in one lay. Replace end

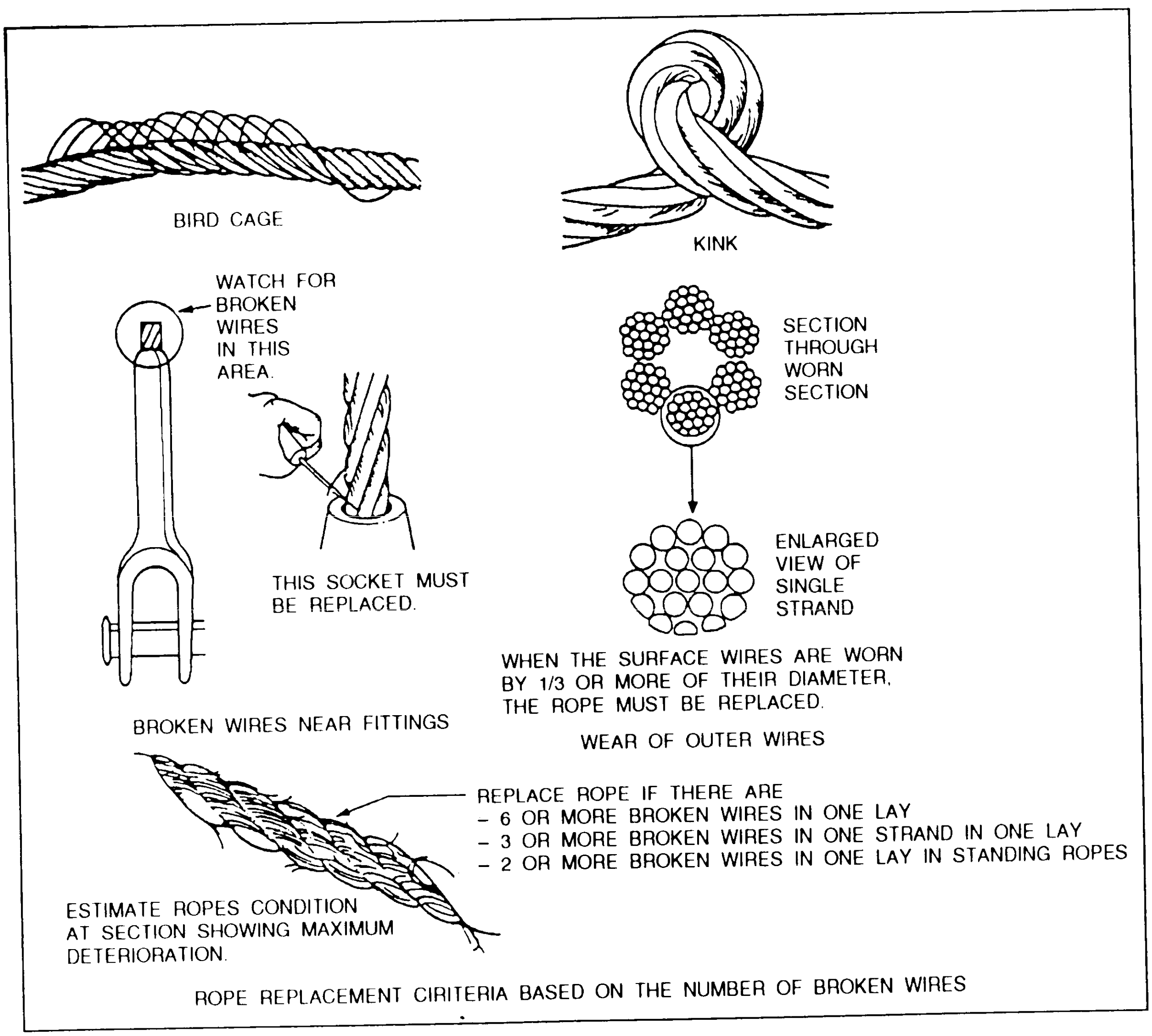


Figure 12-36.—Common wire rope defects.

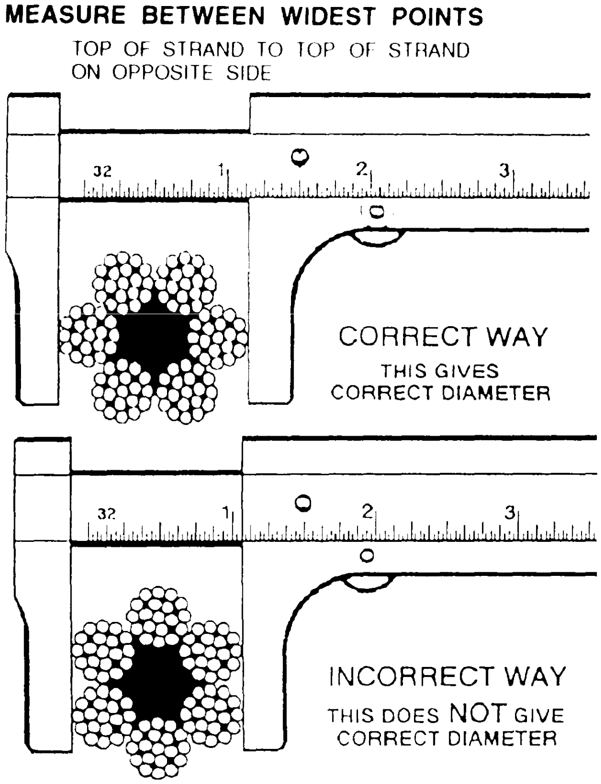


Figure 12-37.—Measuring wire rope.

connections when there are any broken wires adjacent to the end connection.

2. Boom pendant wire ropes. More than two broken wires in one lay in sections beyond the end connection or one or more broken wires at an end connection.

3. Kinks or crushed sections. Severe kinks or crushed rope in straight runs where the wire rope core is forced through the outer strands.

4. Flattened section. Flat sections where the diameter across the flat section is less than five sixths of the original diameter.

5. Wire rope wear. Measure wire rope with wire rope calipers (fig. 12-37) to check for wear accurately. Replace why rope that has wear of one third of the original diameter of outside individual wires. A crescent wrench can be used as an expedient means to measure wire rope.

Hook Block Inspection

The hook block and the hook are part of the ODCL inspection. The operator must inspect the hook block for cleanliness, binding sheaves, damaged or worn sheaves, worn or distorted sheave pins, broken bolts, and worn cheek weights (fig. 12-38).

The hook is inspected for damage, excessive wear to the hook safety latch, hook swivel trunnions, thrust collar, and securing nut. Also, the hook is inspected for damage or missing lubrication fittings, proper lubrication, cracks and gouges, and if visibly bent or twisted.

Sheave Inspection

The sheaves inspection (fig. 12-39) is the inspection for wear and damage, wear in the wire rope sheave groove, loose or damage sheave guards, and worn bearings and pins. Sheaves rotate on either bearings or bushings that are inspected for discoloration (due to

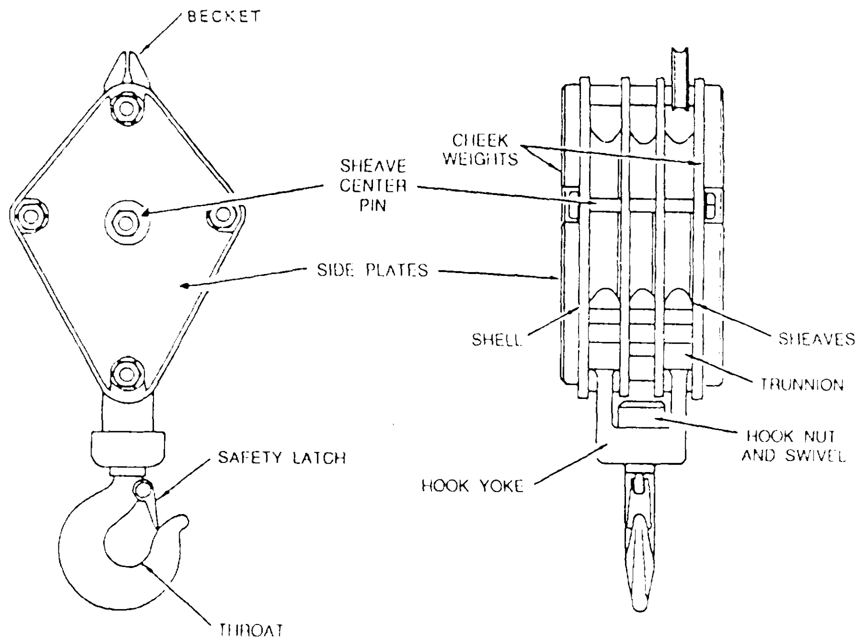


Figure 12-38.-Hook and block inspection points.

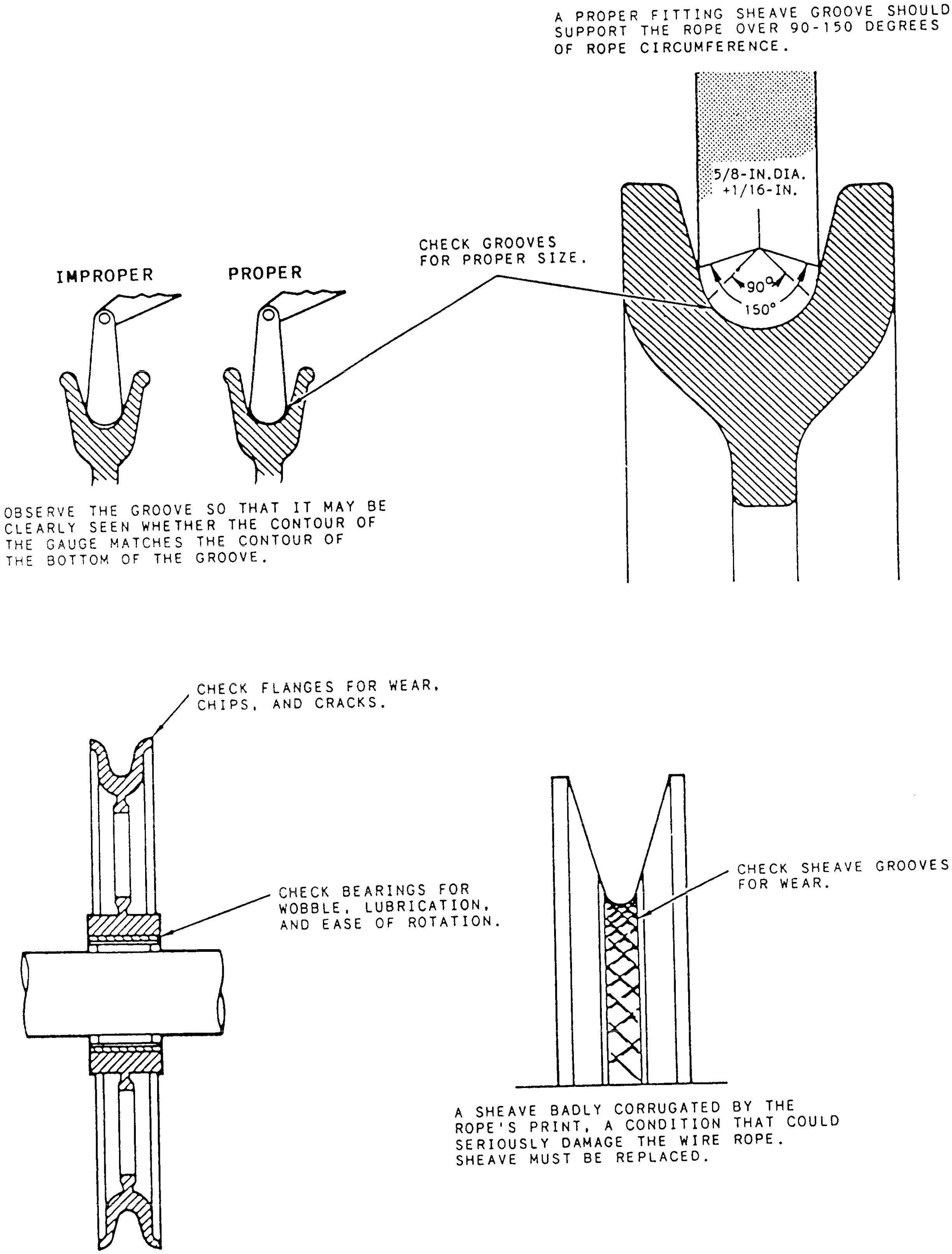


Figure 12-39.-Sheave (pulley) inspection.

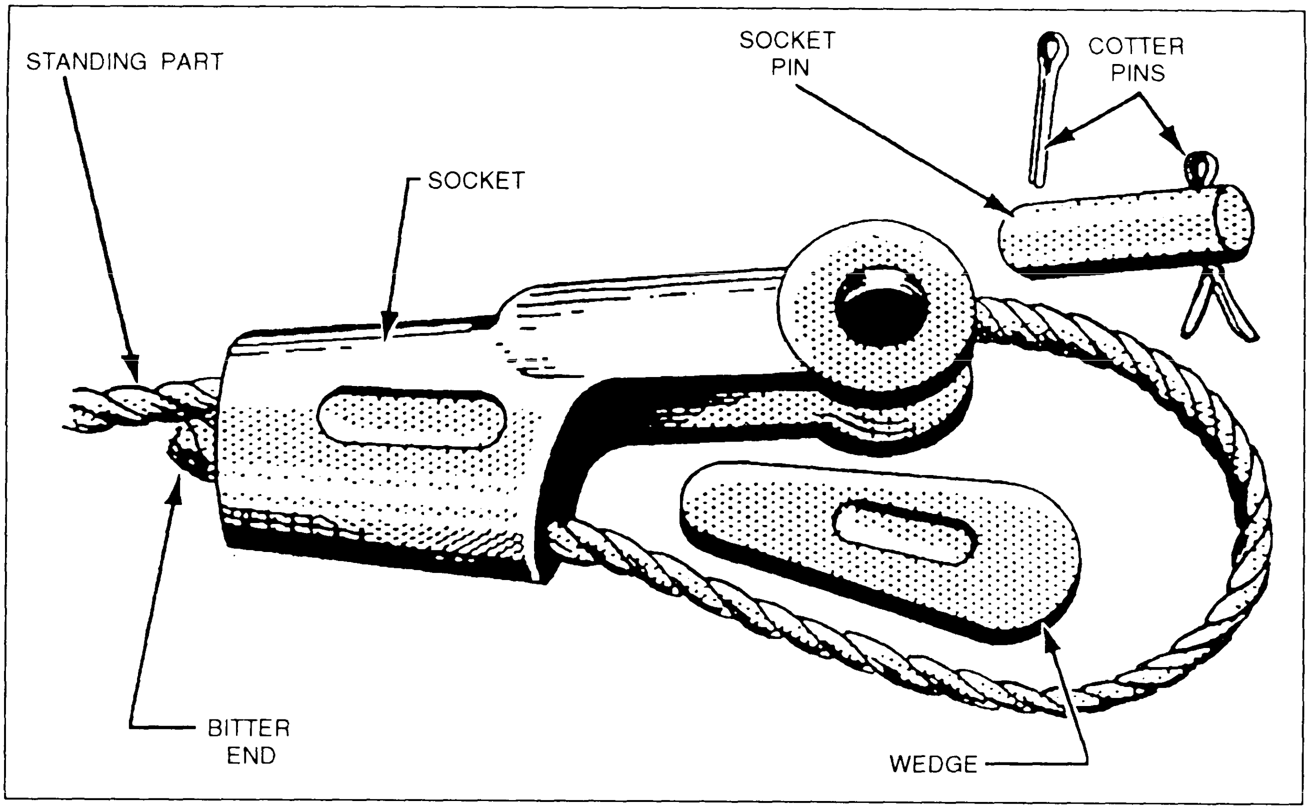


Figure 12-40.-Wedge socket.

excessive heat), metallic particles, chips or displaced metal, broken or distorted bearing retainer or seals, adequate lubrication, and tight bearing caps.

Wire Rope End Connections

Wire rope end connections must be as specified by the manufacture. The most common type of end connection used in the NCF is the wedge socket (fig. 12-40).

Wedge sockets develop only 70 percent of the breaking strength of the wire rope due to the crushing action of the wedge. Swage socket, cappel socket, and zinc (spelter) socket wire rope end connections all provide 100 percent of the breaking strength of the wire rope when properly made.

Exercise caution when wedge socket connections are used to make rated capacity lifts. Wedge sockets are particularly subject to wear, faulty component fit, and damage from frequent change outs, and are highly vulnerable to inadvertent wedge release and disassembly in a two-blocking situation.

NOTE: Two-blocking is hoisting the hook block sheaves against the boom tip sheaves.

Wedge sockets must be installed as specified in the following procedures:

1. Cut and remove any section of wire rope used in a socket that was subject to sharp bending and crushing before resocketing.

2. Install the wedge socket carefully, so the wire rope carrying the load is in direct alignment with the eye of the socket clevis pin. This ensures the load pull is direct.

3. Place the socket upright and bring the rope around in a large, easy-to-handle loop. Extend the dead end of the wire rope from the socket for a distance of at least one rope lay length. Insert the wedge in the socket, permitting the rope to adjust around the wedge.

4. As a safety precaution, install a wire rope clip on the dead end of the wire rope that comes out of the wedge socket (fig. 12-41). Measure the distance from the base of the wedge socket to the clamp. This measurement is used as a guide to check if the wire rope is slipping in the wedge socket.

NOTE: Do not attach the wire rope clip to the dead end and live end of the wire rope that comes out of the

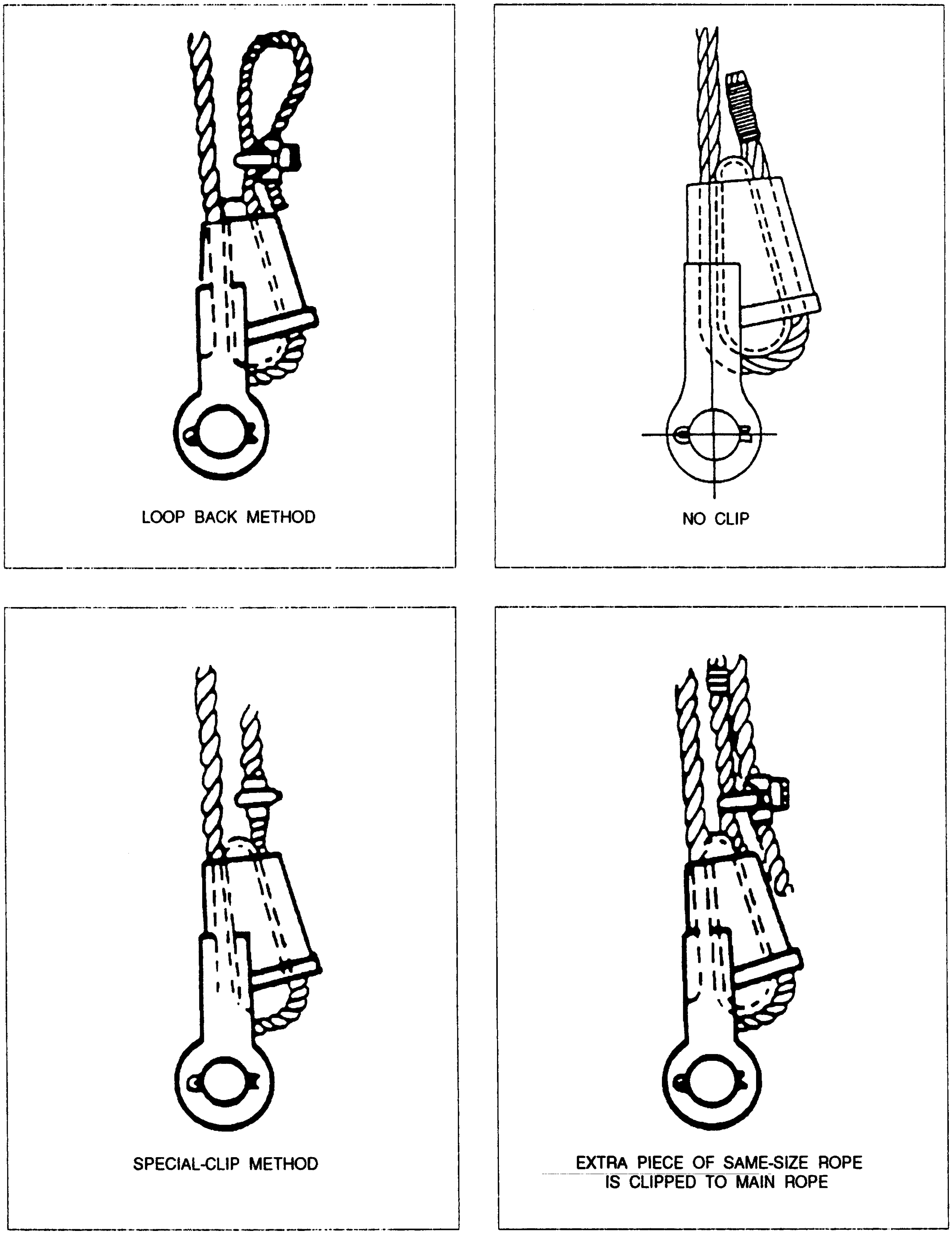


Figure 12-41.—Wedge socket clip method.

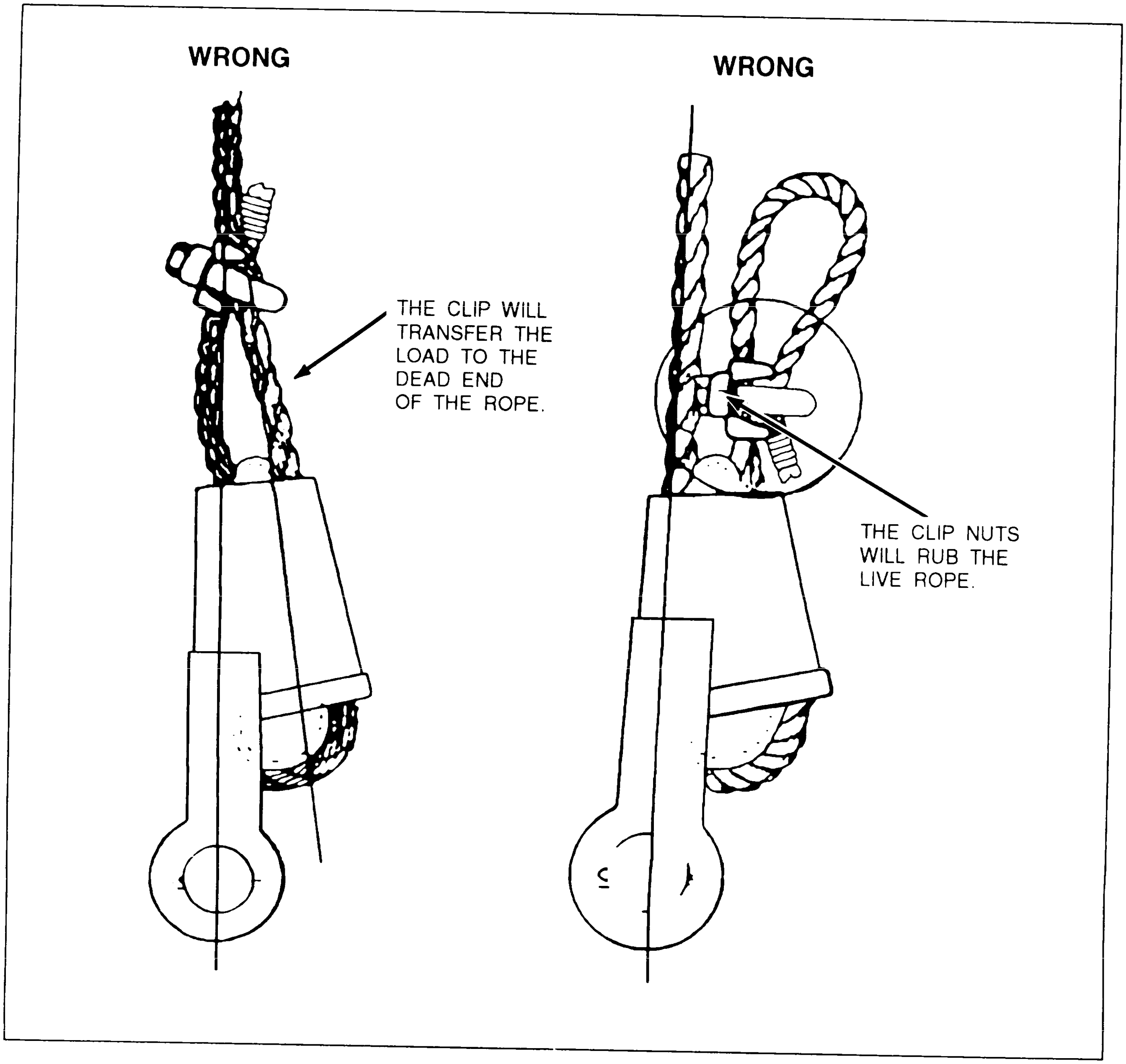


Figure 12-42.—Improper wire rope clip placement.

wedge socket. Improper wire rope clip placement is shown in figure 12-42.

5. Secure the socket to a support and carefully take a strain on the live side of the rope to ensure the proper initial seating of the wedge. Increase the load gradually until the wedge is fully seated. Avoid sudden shock loads.

CRANE LIFT CHECKLIST

The Crane Lift Checklist (fig. 12-43), outlined in the COMSECOND/COMTHIRDNCBINST 11200.1, must be filled out by the crane crew supervisor or the crane test director before the crane can proceed to any project or make any crane lift. After the Crane Lift Checklist is complete, the crane crew supervisor briefs the operator and rigger on specifics of the lift and travel conditions.

Crane Stability

Setting up for a crane lift is the most critical portion of the crane operation. The most common causes of crane mishaps are as follows:

CRANE LIFT CHECKLIST

Date ____________________

1. Location of lift: ____________________
2. Supervisor responsible for lift: ____________________
3. Crane operator: ____________________
4. Rigger(s)/helper(s): ____________________
5. Lift: ____________________

   a. Description of lift:

   b. Weight of item to be lifted: ____________________

   c. Was weight estimated: Yes: ___ No: ___ If yes, by whom: ____________________
   Can weight be verified? Yes: ___ No: ___ If no, contact the crane certifying officer for further instructions.

6. Crane assigned to lift:

   a. USN #: ____________

   b. Capacity: ____________

7. Is travel route free of unsafe obstacles: Yes: ___ No: ___
   If no, explain:
8. Have travel permits been obtained (if required)?
   Yes: ___ No: ___ N/A: ___
9. Have operators and riggers been briefed on sequence to be followed during lift?
   Yes: ___ No: ___ If no, explain:
10. Has crane setup been inspected for stability?
    Yes: ___ No: ___ If no, explain:
11. Has crane operating area been inspected?
    Yes: ___ No: ___ If no, explain:
12. Have slings and other hardware being used been inspected?
    Yes: ___ No: ___ If no, explain:

Figure 12-43.-Crane Lift Checklist.

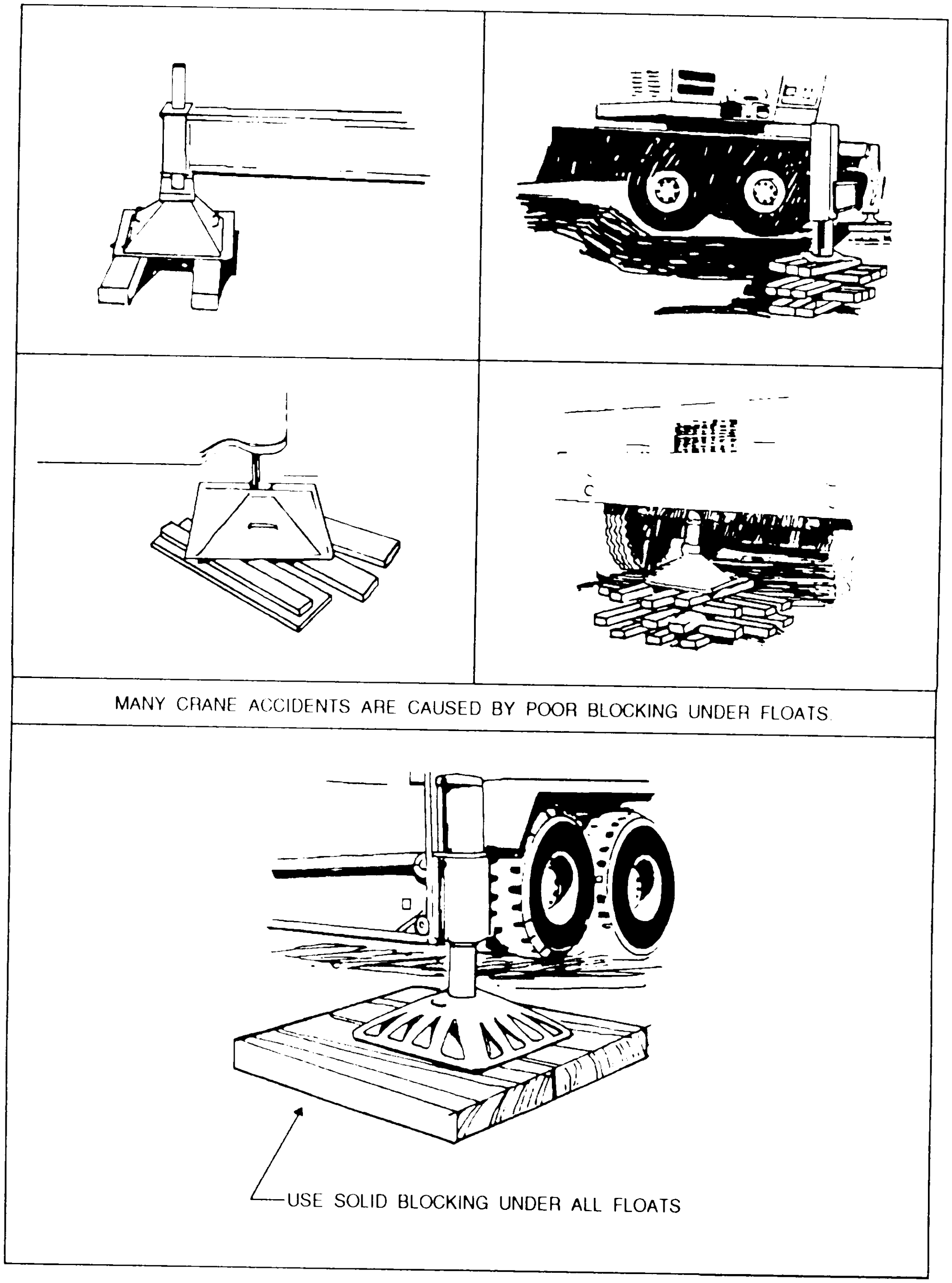


Figure 12-44.-Proper and improper cribbing.

Boom Length and Lift Radius	Chart Capacity Lost When Crane Out of Level By 1°	2°	3°
Short Boom, Minimum Radius	10%	20%	30%
Short Boom, Maximum Radius	8%	15%	20%
Long Boom, Minimum Radius	30%	41%	50%
Long Boom, Maximum Radius	5%	19%	15%

Figure 12-45.-Crane capacity lost by crane out of level.

1. Failure to block/crib under the outrigger pads when poor ground conditions cannot support the total weight of the crane and load. Proper and improper cribbing is shown in figure 12-44.

2. Failure to extend the outriggers fully and use them following the manufacturer's instruction.

3. Failure to note overhead obstructions, such as overpasses and power lines.

4. Failure to level the crane. Leveling the crane cannot be overemphasized. Cranes must be set up as per manufacturer's instruction with the outriggers fully extended and the crane leveled. Crane capacity is lost when the crane is out of level by only a few degrees (fig. 12-45). Most cranes have levels mounted on them, but the levels are not always accurate. Use a 3-foot builders level to check the level of the crane over the rear and over the sides (fig. 12-46).

Load Capacity

The rated capacities of mobile cranes are based on both **strength** and **stability.** Manufacturers of cranes will normally denote on the load charts a shaded area or a bold line across the chart dividing the lifting capacities based on strength or stability of the crane. It is extremely important to know the difference for, in one case, one of the structural components of the crane will break and, in the other case, the crane will tip over.

Additionally, the following factors must be recognized and the capacity adjusted accordingly:

1. Do not use stability to determine lifting capacity. Use the load chart installed by the crane manufacturer. The load chart is securely attached in the operator's cab.

2. The number of parts of line on the hoist and the size and type of wire rope for various crane loads.

3. Length of boom.

4. Boom angle.

5. Boom pendant angle (when the telescopic/folding gantry is down, the angle decreases and the stress increases).

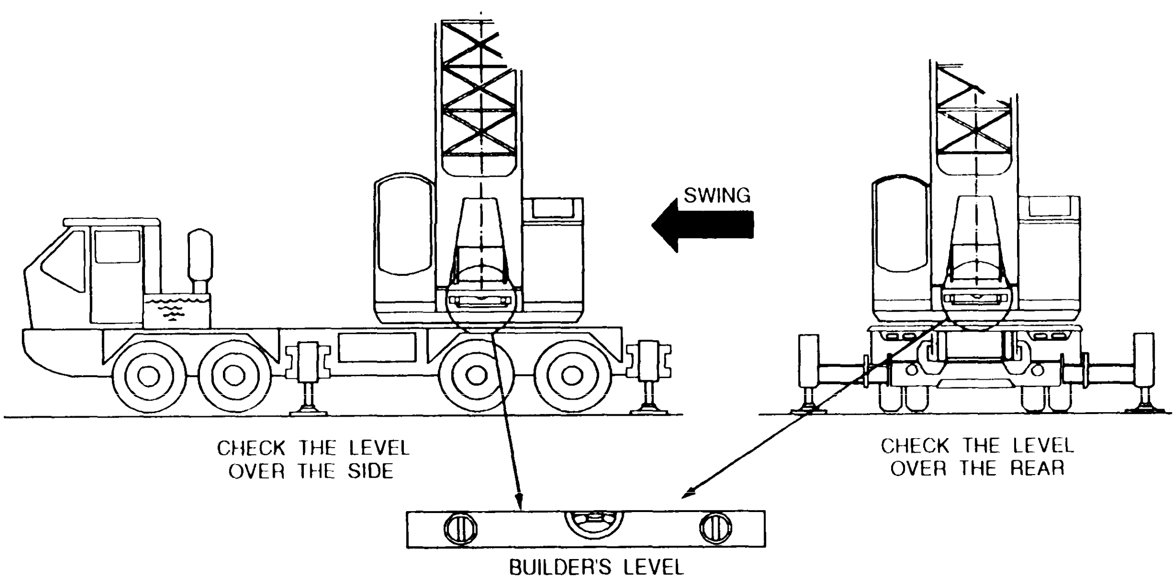


Figure 12-46.-Leveling procedures using a builder's level.

6. Gantry and/or live mast in the highest position.

7. Quadrant of operation (that is, over the side, over the rear capacities).

Load Rating Chart

Atypical load rating chart is shown in figure 12-47. To determine the capacity of the crane by using the load chart, the operator must know the length of boom, the load radius, the boom angle, and if the lift is to be performed over the side or over the rear.

When performing lifts using the boom angle indicator that indicates an angle not noted on the load chart, use the next lower boom angle noted on the load chart for determining the capacity of the crane. For example, using the load charts in figure 12-47, the crane is rigged with 60 feet of boom, and the boom angle indicator indicates a boom angle of 57 degrees. A 57-degree boom angle load capacity is not noted on the load chart, so you must use the next lower noted boom angle of 53 degrees for determining the capacity of the crane.

NOTE: Do not rely on the boom angle indicator for radius accuracy when lifts exceed 75 percent of the rated capacity. Measure the radius to avoid the possibility of error.

When using a radius measurement not noted on the load charts, use the next longer radius measurement noted on the load chart for determining the capacity of the crane. For example, using the load charts in figure 12-47, the crane is rigged with 50 feet of boom, and the radius measurement is 32 feet. A 32-foot radius measurement is not noted on the load charts, so you must use the next longer radius measurement of 35 feet noted on the load chart for determining the capacity of the crane.

The number of part lines reeved on the main hoist block can affect the capacity of the crane. If the crane is capable of being reeved with an eight-part line and the reeving is changed to a six-part line, the capacity of the crane changes. On newer models of cranes, the capacity for different parts of line configurations is noted on the load charts. On older models, you must refer to the manufacturer's manual.

The load chart provides the capacity of the crane with outriggers set and without outriggers. "Outriggers set" means the outriggers are fully extended and the weight of the crane is off of the suspension system or the tires are off the ground. If a situation arises where the outriggers cannot be fully extended, you must use the without outriggers load capacity ratings.

NOTE: Load capacities change when swinging from each quadrant of operation, such as from over the rear to over the side.

SAFE LIFTING

The following factors are basic guidelines to perform safe daily crane operations:

1. Determine the weight to be lifted and the crane required to make the lift safely.

2. Travel the proposed route the crane will follow to and from the project site, and complete the Crane Lift Checklist.

3. Obtain the travel permits if required.

4. Brief operators and riggers on the specifics of the lift and travel conditions.

5. Inspect the crane area setup for stability and safe operating area

6. Fully extend the outriggers and use them according to the manufacturer's instruction.

7. Check the crane for levelness.

8. Inspect all rigging hardware.

9. Select the proper sling with sufficient capacity rating.

10. Center the sling in the base (bowl) of the hook to avoid hook point loading, and ensure the hook block is always placed over the center of the load to eliminate shock loading of the slings or cranes, resulting from load shifts when a lift is made.

11. Make ample safety allowances for unknown factors.

12. Stand clear of and do not walk under suspended loads.

13. Boom deflection. All crane booms have deflection. When the load is lifted off the ground, the boom will deflect, causing the radius to increase. Increased radius may cause overloading of the crane.

14. An uncontrolled swinging load can cause the radius to increase.

15. Clean operating area. Water coolers, excess tools, grease, soda cans, and other unnecessary items should be kept outside of the operating area of the crane. Water coolers must be kept off the crane to prevent

MAXIMUM ALLOWABLE LOADS - CRANE SERVICE								
BOOM LENGTH IN FEET	LOAD RADIUS IN FEET	BOOM ANGLE IN DEGREES	BOOM POINT PIN HEIGHT	WITH OUTRIGGERS SET*		WITHOUT OUTRIGGERS		
				OVER SIDE	OVER REAR	OVER SIDE		OVER REAR
						8'-0" WIDE	9'-0" WIDE	9' OR 9' WIDE
30	10	78	35'6"	*50,000	*50,000	28,800	32,200	39,300
	12	74	35'0"	*50,000	*50,000	22,500	24,900	30,800
	15	68	34'0"	*50,000	*50,000	16,800	18,500	23,200
	20	57	31'3"	36,800	*43,700	11,700	12,800	16,200
	25	44	27'3"	26,000	31,100	8,800	9,700	12,400
40	12	78	45'3"	*50,000	*50,000	22,200	24,600	30,600
	15	74	44'6"	*50,000	*50,000	16,500	18,200	22,900
	20	66	42'9"	36,600	*41,300	11,400	12,500	16,000
	25	58	40'0"	25,800	30,900	8,600	9,400	12,200
	30	49	36'3"	19,800	23,700	6,800	7,400	9,700
	35	38	30'9"	15,900	19,100	5,500	6,050	8,000
50	15	77	55'0"	*50,000	*50,000	16,400	18,000	22,700
	20	71	53'6"	36,500	*40,000	11,300	12,300	15,800
	25	65	51'6"	25,700	*30,400	8,450	9,250	12,000
	30	58	48'9"	19,600	23,600	6,650	7,250	9,500
	35	51	45'0"	15,800	19,000	5,400	5,900	7,800
	40	43	40'6"	13,100	16,800	4,500	4,900	6,600
	45	34	34'0"	11,200	13,500	3,800	4,150	5,650
60	15	79	65'3"	*48,800	*48,800	16,100	17,800	22,500
	20	74	64'0"	36,400	*39,100	11,000	12,100	15,600
	25	69	62'3"	25,500	*29,600	8,150	8,950	11,800
	30	64	60'0"	19,500	23,400	6,350	7,000	9,300
	35	59	57'3"	15,600	18,800	5,100	5,650	7,600
	40	53	53'9"	13,000	15,700	4,200	4,650	6,400
	45	46	49'6"	11,000	13,300	3,500	3,900	5,350
	50	39	44'3"	9,500	11,600	2,950	3,300	4,700
	55	32	37'9"	8,400	10,200	2,500	2,800	4,000
70	20	77	74'3"	36,200	*37,300	10,700	11,800	15,400
	25	72	73'0"	25,300	*28,800	7,850	8,700	11,600
	30	68	71'0"	19,300	*23,100	6,100	6,700	9,100
	40	59	66'0"	12,800	15,500	3,900	4,350	6,200
	50	49	58'6"	9,350	11,400	2,700	3,000	4,500
	60	36	47'6"	7,200	8,850	1,850	2,150	3,350
80	20	78	84'6"	*32,800	*32,800			
	25	75	83'3"	23,200	*28,400			
	30	71	81'9"	19,100	*22,600			
	40	63	77'6"	12,600	15,300			
	50	55	71'3"	9,200	11,200			
	60	45	62'9"	7,050	8,700			
	70	34	50'9"	5,600	6,950			
90	20	80	94'9"	*29,000	*29,000			
	25	77	93'9"	25,100	*26,000			
	30	73	92'3"	19,000	*22,200			
	40	66	88'6"	12,500	15,200			
	50	59	83'3"	9,050	11,000			
	60	51	76'3"	6,900	8,550			
	70	43	66'9"	5,450	6,800			
	80	32	53'6"	4,400	5,600			
100	20	81	105'0"	*25,300	*25,300			
	30	75	102'9"	18,800	*20,500			
	40	69	99'3"	12,300	15,000			
	50	63	94'9"	8,850	10,800			
	60	56	88'9"	6,700	8,400			
	70	49	81'0"	5,250	6,600			
	80	40	70'6"	4,200	5,350			
	90	30	56'3"	3,350	4,400			
110	20	81	115'0"	*22,000	*22,000			
	30	76	113'0"	*17,700	*17,700			
	40	71	110'0"	12,100	*14,000			
	50	65	106'0"	8,650	10,700			
	60	59	100'6"	6,500	8,200			
	70	53	93'9"	5,050	6,450			
	80	46	85'3"	4,000	5,200			
	90	38	74'3"	3,200	4,250			
	100	29	59'0"	2,600	3,500			

Figure 12-47.-Typical crane capacity chart.

people from congregating around the crane when in operation.

NOTE: Safe lifting is paramount! Project completion must not interfere with safe crane operations.

CLAMSHELL OPERATIONS

The clamshell bucket is an attachment used with a crane for vertical digging belowground level and for placing materials at considerable height, depth, or distance. You can also use it for moving bulk materials from stockpiles to plant bins, loading hoppers, and conveyors. It can be used to dig loose to medium compacted soil.

Clamshell operating procedures are as follows:

1. Position and level the crane, ensuring the digging operation is as close to the radius as the dumping operation. This prevents you from having to boom up and down, resulting in a loss of production.

2. Select the correct size and type of bucket for the crane.

3. When lowering the clamshell bucket, if too much pressure is applied to the closing line brake, the bucket will close and an excess amount of wire rope will unwind from the holding line hoist drum. To avoid this, you should release the holding line and closing line brakes simultaneously when lowering the open clamshell into the material for the initial bite. Engage the closing line control lever to close the bucket. Control the digging depth by using the holding line control lever and brake.

4. If, during hoisting, the hoist line gets ahead of the closing line, the bucket will open and spill the material. (This could also be caused by having too much wire rope on the hoist drum.) The operator must hoist both the closing and holding lines at the same speed to keep the bucket from opening and spilling material.

5. When the clamshell bucket is raised enough to clear all obstacles, start the swing by engaging the swing control lever. Hoisting the bucket can be performed, as it is swung to the dumping site. The spring-loaded tag line will retard the twisting motion of the bucket if the swing is performed smoothly.

6. Dumping and unloading the clamshell is performed by keeping the holding line brake applied while the closing line brake is released. Apply the closing line brake quickly after the load is dumped to prevent the closing line from unwinding more wire rope than is needed to dump the material. After the bucket is emptied, swing the open clamshell back to the digging site. Then lower the open bucket and repeat the cycle.

The clamshell operating cycle has four steps: filling (closing) the bucket, raising the loaded bucket, swinging, and dumping. The boom angle for clamshell operations should be between 40 to 60 degrees. Be careful when working with higher boom angles, as the bucket could hit the boom. A clamshell attachment is not a positive digging tool.

The height reached by the clamshell depends on the length of the boom used. The depth reached by the clamshell is limited by the length of wire rope that the hoist drum can handle. For the safe lifting capacity for the clamshell, refer to the operator's manual and the crane capacity load chart.

DRAGLINE OPERATIONS

The dragline is a versatile attachment capable of a wide range of operations at and belowground level. The dragline can dig through loose to medium compacted soil. The biggest advantage of the dragline over other machines is its long reach for both digging and dumping. Another advantage is its high cycle speed. The dragline does not have the positive digging force of the backhoe. The bucket is not weighted or held in alignment by rigid structures; therefore, it can bounce, tip over, or drift sideways when digging through hard materials. This weakness increases with digging depth.

Dragline operating procedures are as follows:

1. Keep the teeth sharp of the dragline bucket and built up to proper size.

2. Keep the dump rope short, so the load can be picked up at a proper distance from the crane.

3. Excavate the working area in layers, not in trenches, and sloped upward toward the crane.

4. Do not drag the bucket in so close to the crane that it builds piles and ridges of material in front of the crane.

5. Do not guide the bucket by swinging the crane while digging. This puts unnecessary side stresses on the boom. Start the swing only after the bucket has been raised clear of the ground.

6. A pair of drag chains is attached to the front of the bucket through brackets by which the pull point may be adjusted up or down. The upper position is used for deep or hard digging, as it pulls the teeth into a steeper angle.

7. The drag cable can be reversed end for end to prolong the life of the wire rope, reduce early wire rope replacement, and keep wire rope cost down. Remember, the drag cable should not be lubricated.

8. When lowering the dragline bucket into the area to be worked, release the drag brake to tip the cutting edge down and then release the hoist brake. You do not have to drop the bucket to force the teeth into the material. The bucket is filled as it is dragged toward the crane by engaging the drag control lever. The cutting depth is controlled by releasing tension from the hoist brake. The dragline is NOT a positive digging tool.

9. The dragline cycle is filling the bucket, lifting the bucket, swinging the loaded bucket, and dumping the load.

10. Since the dragline is not a rigid attachment, it will not dump materials as accurately as do other excavators. When a load is dumped into a haul unit or hopper, you need more time to position the bucket before dumping it.

NOTE: When you are dumping into a haul unit, NEVER load over the cab. Additionally, make sure the operator is out of the cab and clear of the dragline or clamshell bucket.

11. The boom angle for dragline operations should normally be from 25 to 35 degrees. However, check the crane load chart to ensure this low boom angle does not exceed the capacity of the crane. At this relatively low boom angle, you must be careful when excavating and dumping wet, sticky materials, because the chance of tipping the crane is increased because the material tends to hang in the bucket.

Dragline Employment

The dragline can be used in dredging where the material handled is wet and sticky. It can dig trenches, strip overburden, clean and dig road side ditches, and slope embankments. When the dragline is handling mud, it is the most practical attachment. Its reach enables it to handle a wide area of excavation while sitting in one position, and the sliding action of the bucket eliminates trouble with suction.

Other uses of the dragline include the following:

1. In-line approach. When excavating a trench with the dragline, ensure the dragline and carrier unit are centered on the excavation (fig. 12-48). The dragline cuts or digs to the front and dumps on either side of the excavation. The crane moves away from the face as the work progresses.

2. Parallel approach. The dragline can slope an embankment better by working it from the bottom to the top. The crane is positioned on the top with the carrier parallel to the working face, so it can move the full length of the job without excessive turning.

3. Drainage. A dragline is ideal if earthwork materials have to be removed from a trench, canal, gravel pit, and so forth, containing water. Plan the work to begin at the lowest grade point, so drainage will be provided as the dragline progresses towards higher levels.

NOTE: Digging underwater or in wet materials increase the weight of the materials and frequently prevent carrying heaped bucket loads.

Ditching the excavation through swamps or soft terrain is common. Under these conditions the excavated material is normally cast onto a levee or spoils bank.

4. Loading haul units. When the job requires excavated material to be loaded into hauling units, the excavation should be opened up so loaded hauling equipment can travel on high, dry ground or on better grades. The spotting of trucks and dragline should be planned for minimum boom swing with the truck bed under the boom point and the long axis of the bed parallel with the long axis of the boom or at right angles to the boom. More spillage is to be expected from a dragline than from a front-end loader.

Efficient Dragline Operation

Other uses of the dragline operation include the following:

1. Although the dragline bucket can be readily cast beyond the length of the boom, the machine should be positioned to eliminate casting.

2. Use heavy timber mats for work on soft ground. The mats should be kept level and clean.

3. When setting up for a dragline operation, you should have access for maintenance, operating personnel, and hauling equipment.

4. Excavate the working area in layers, not in trenches, and keep the slope upward toward the crane.

5. Do not drag the bucket in so close to the crane that it builds piles and ridges of material in front of the crane.

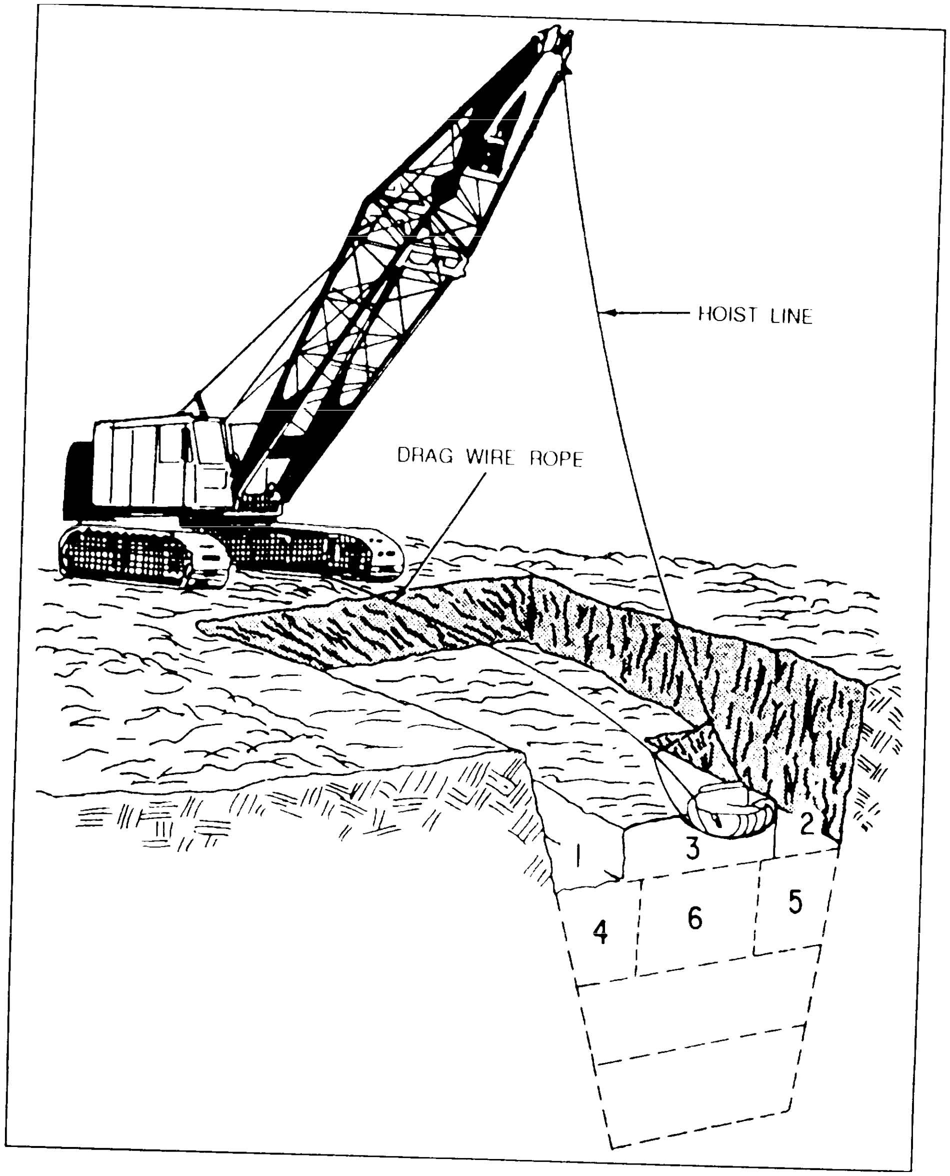


Figure 12-48.-In-line approach with dragline.

6. Salvage pieces of hoist wire rope for use as the dump rope.

PILE-DRIVING OPERATIONS

Pile driving in the NCF is done with crawler- or truck-mounted cranes rigged with pile-driving attachments, as shown in figure 12-49. The pile-driving hammer is categorized under the 36-00000 USN number registration series.

NOTE: The combined weight of all the pile-driving attachments reduces the capacity of the crane. Additionally, the crane capacity must be able to support the combined weight of all of the pile-driving attachments.

LEADS

Pile-driving leads serve as tracks along which the pile-driving hammer runs and as guides for positioning and steadying the pile during driving operations. The leads come in 10-, 15-, and 20-foot sections bolted together to form various lengths, as shown in figure 12-50.

NOTE: Because of the vibrations created during pile-driving operations, you must check all the lead

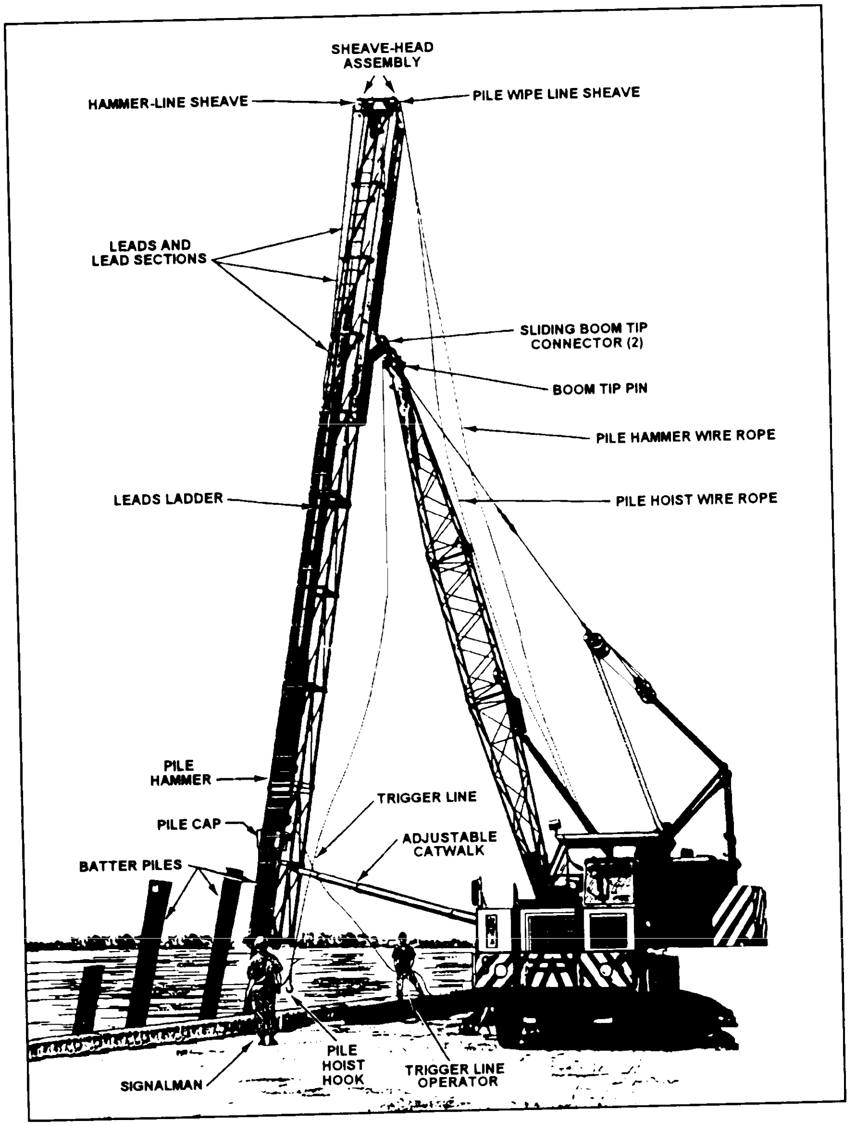


Figure 12-49.—Typical pile-driving operation.

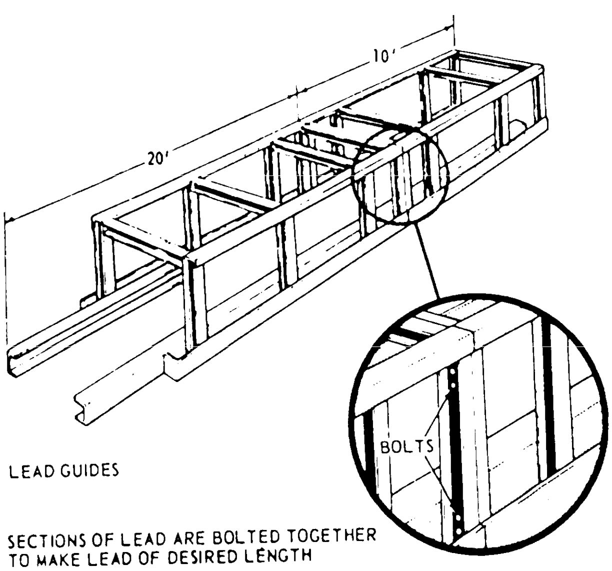


Figure 12-50.-Assembly of 10- and 20-foot lead sections.

section bolts for tightness at the beginning of each pile-driving shift.

The types of leads used in the NCF are swinging, underhung, extended four-way, and spud leads.

Swinging Leads

Swinging leads are assembled facedown on the ground by bolting the 15-foot tapered section to the selected intermediate sections. A single crane line holds the pile-driving hammer that is slipped into and guided by the rails of the swinging leads. This lead is hung from the crane boom with a second single line from the crane. The lead is spotted on the ground at the pile location, normally with stabbing points attached to the bottom of the leads, and held plumb or at the desired batter with the second single crane line. Short swinging leads are often used to assist in driving steel sheetpilings. Figure 12-51 shows the components of a swinging lead.

The boom point sheaves are used to accommodate the hoist drum wire rope that supports the pile, pile-driving hammer, and leads; therefore, its use requires a three-drum crane. Under certain conditions a two-drum crane can be used The leads are raised to the vertical by a combination of booming, swinging, and/or traveling.

ADVANTAGES.— Some advantages of using a swinging lead over other types of leads are as follows:

1. They are the lightest, simplest, and least expensive.

2. With stabbing points secured in the ground, these leads are free to rotate sufficiently to align the pile-driving hammer with the pile without precise alignment of the crane with the pile.

3. Because these leads are generally 15 to 20 feet shorter than the boom, the crane can reach out farther if the crane has sufficient capacity.

4. They can be used to drive piles in a hole, ditch, or over the edge of an excavation.

5. For long lead and boom requirements, the weight of the leads can be supported on the ground and the pile is lifted into place without excessively increasing the working load weight.

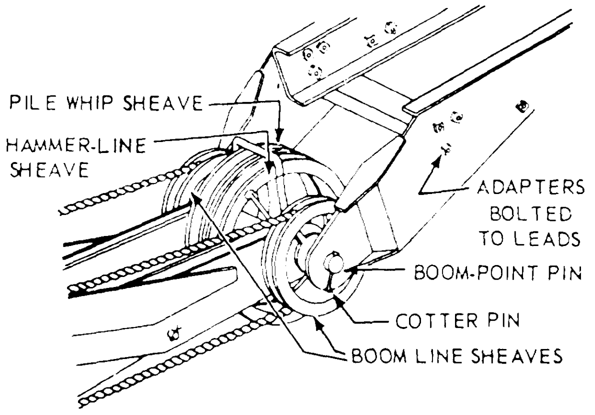


Figure 12-52.-Lead adapters connected to the boom tip.

DISADVANTAGES.— Some disadvantages of using a swinging lead are as follows:

1. It requires a three-hoist drum crane (main line for the pile, secondary for the pile-driving hammer, and third for the leads) or two-hoist drum crane with the lead hung on the sling from the boom tip.

2. Because the leads are supported by the hoist wire rope, precise positioning of the leads with the top of the pile is difficult and slow.

3. If stabbing points are not secured to the ground, it is difficult to control the twisting of the leads.

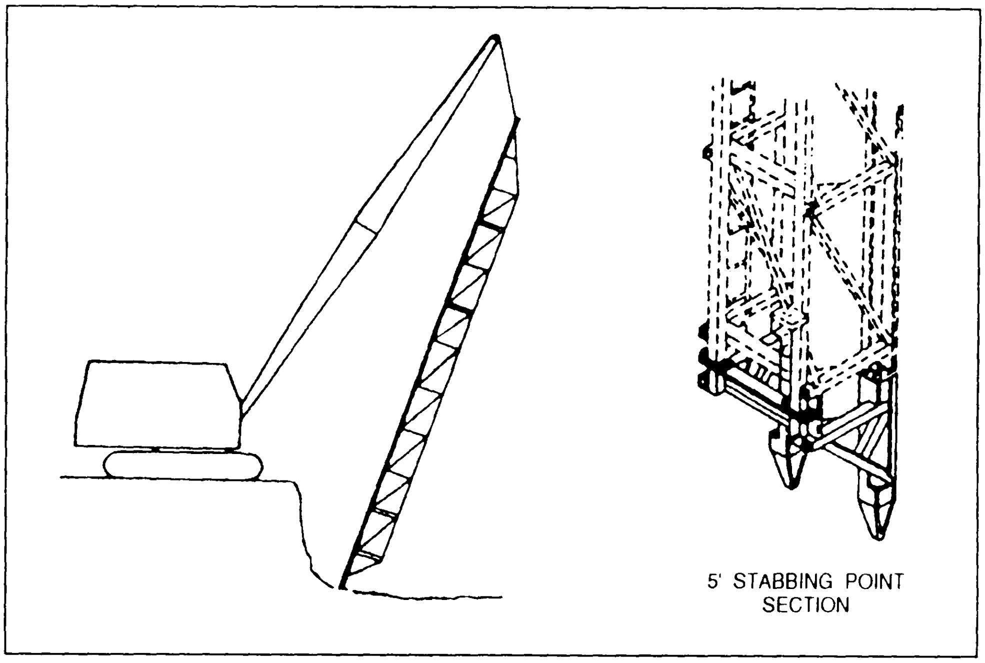


Figure 12-51.-Swinging leads.

NOTE: The tag line winder may be used to control the twisting of the leads.

4. Because these leads are not rigid, it is more difficult to position the crane to set up for pile-driving operations.

Underhung Leads

Underhung leads are composed of exactly the same sections used for swinging leads. Underhung leads are bolted together on the ground, as described for swinging leads, and connected to the boom tip through the use of lead adapters (fig. 12-52). The boom tip sheaves are used to accommodate the pile and the pile-driving hammer. All underhung leads have a standard bolt hole layout for bolting the lead adapters to the leads; however, the dimensions of the boom tip end of the adapters vary according to the make and model of the crane. After the adapters are connected to the boom, the boom is raised to bring the leads to a vertical position (fig. 12-53). Long lead sections may require the use of support equipment to raise the leads to a vertical position.

NOTE: Check the adapter bolts for tightness at the beginning of each pile-driving shift.

Adapter plates are mounted to the boom butt or crane cab and on the bottom lead section for connection of a fore-and-aft bottom brace, commonly known as a **catwalk.** The catwalk can be extended or telescoped to various lengths. It can be set to hold the leads vertical for driving bearing piles or to hold them at an angle for driving batter piles. In use, an underhung lead is held by the boom at a fixed radius (fig. 12-54).

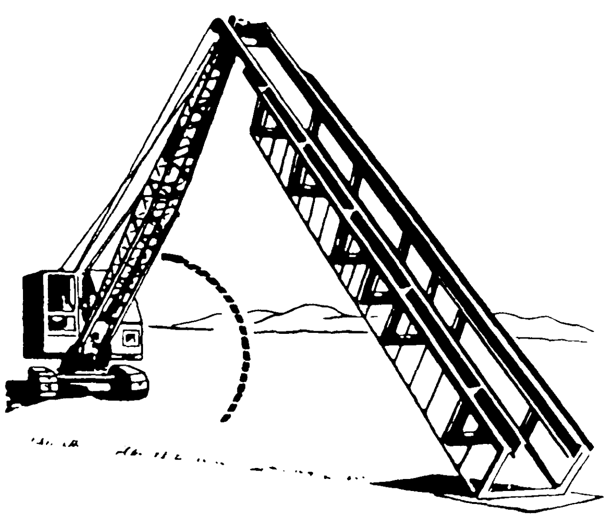


Figure 12-53.-Underhung leads being raised by the boom.

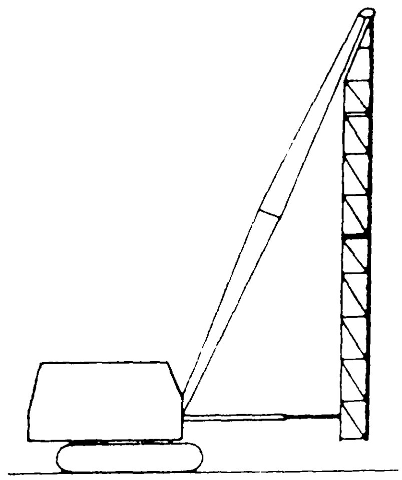


Figure 12-54.-Underhung leads.

ADVANTAGES.— Some advantages of using underhung leads over other types of leads areas follows:

1. They are lighter and generally less expensive than the extended four-way type of lead.

2. They require only a two-hoist drum crane.

3. They provide accuracy in positioning leads in vertical and fore-and-aft batter positions.

4. They provide precise control of the leads during positioning operation.

5. They reduce rigging time in setting up and breaking down.

6. They use boom tip sheaves.

DISADVANTAGES.— Some disadvantages of using underhung leads are as follows:

1. They cannot be used for side-to-side batter driving.

2. The length of pile is limited by boom length, since this type of lead cannot be extended above the boom tip.

3. When long leads require the use of long boom lengths, the working radius that results may be excessive for the capacity of the crane.

4. They do not allow the use of a boom shorter than the lead.

Extended Four-Way Leads

Extended four-way leads use the same intermediate lead sections as swinging and underhung leads. In place of a 15-foot tapered section, an extended lead uses a

30-foot slide section with a sheave head **assembly.** A universal **sliding boom tip connector,** slipped into the 30-foot slide section, connects to the boom tip (fig. 12-55). The sliding boom tip connector swivels, allowing for driving batter piles in all directions.

The boom is lowered over the leads when connecting the boom tip to the sliding boom connector. The connector is bolted into the 30-foot slide section at the location dictated by the amount of lead extension desired above the boom tip.

NOTE: Extension of the lead over the boom tip must not exceed one third of the total lead length or up to 25 feet maximum.

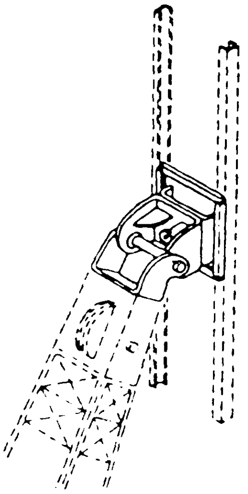


Figure 12-55.-Sliding boom tip connector.

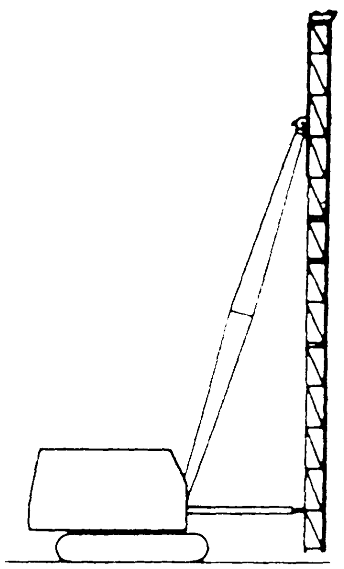


Figure 12-56.-Extended four-way lead.

The boom is raised to raise the leads. The type of catwalk used is a hydraulic or mechanical **parallelogram bottom brace.** This type of brace allows for a fixed radius or side-to-side batter by swinging the linked parallelogram in the desired position. The parallelogram allows for pile driving in all directions at the bottom. Figure 12-56 shows an extended four-way lead.

The boom point sheaves are not used to accommodate the pile-driving hammer and the piles. The extended four-way leads are equipped with a special **sheave head assembly** (fig. 12-57) that the two-hoist drum wire rope reeves through to support the pile-driving hammer and the piles.

ADVANTAGES.— Some advantages of using an extended four-way lead are as follows:

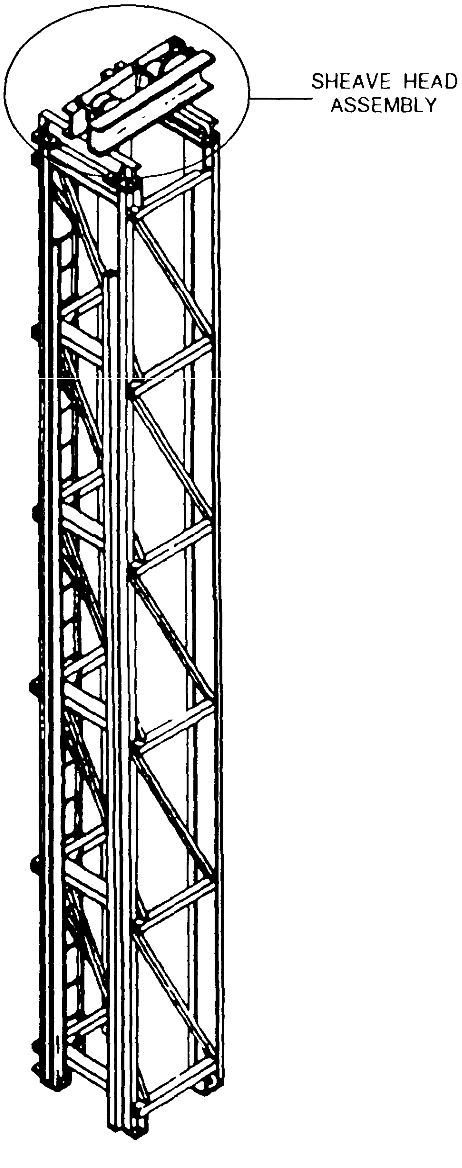


Figure 12-57.-Sheave head assembly.

1. It requires only a two-hoist drum crane.

2. It provides accuracy in locating leads in all batter positions.

3. It provides rigid control of the leads during positioning operation.

4. It allows batter angles to be set and accurately maintained.

5. It allows for the use of short boom angles that increases the crane capacity.

6. The boom can be lowered and leads folded under for short hauls over the road when a crane with adequate capacity is used This operation depends on the length of the lead and boom and the configuration of the crane.

DISADVANTAGES.— Some disadvantages of using an extended four-way lead are as follows:

1. It is the heaviest and most expensive of the three basic lead types.

2. It is more troublesome to assemble.

Spud Leads

A spud lead is a steel wide flange or H-beam used in place of pile-driving hammer leads. The pile-driving hammer rides on the flange of the beam through spud clips bolted to one side of the pile-driving hammer (fig. 12-58).

Depending on the design of the spud lead, the spud can be used as a swinging and underhung lead or equipped with a sheave head assembly as an extended four-way lead An advantage of this type of lead is that it bears the whole bottom of the pile cap to the piling especially when sheetpiling is being driven (fig. 12-59).

PILE-DRIVING HAMMERS

The three principal types of pile-driving hammers are the **drop hammer,** the **steam,** or **pneumatic, hammer,** and the **diesel hammer.**

A drop hammer is a block of metal hoisted to a specific height and then dropped on a cap paced on the butt or head of the pile. Drop hammers weigh from 1,200 to 3,000 pounds.

WARNING

The noise generated by a pile driving operation can cause hearing loss. Hearing protection must be worn by personnel in the vicinity of pile driving operations.

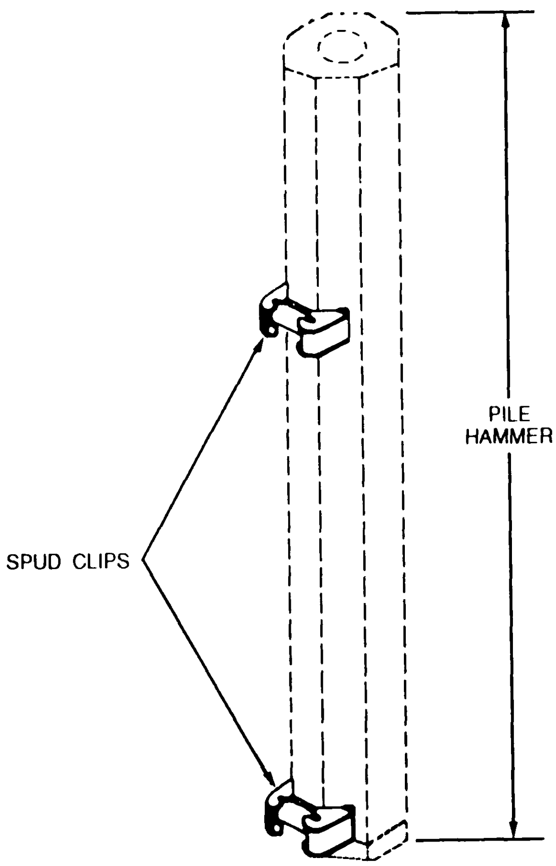


Figure 12-58.-Spud clips mounted to one side of the pile-driving hammer.

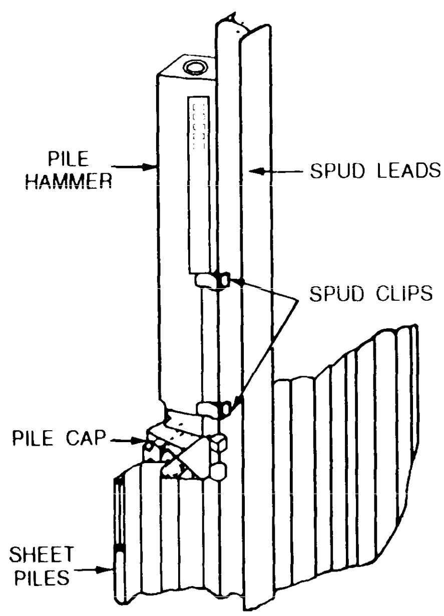


Figure 12-59.-Sheet pile driving with spud leads.

The steam, or pneumatic, hammer has basically replaced the drop hammer. This hammer (fig. 12-60) consists of a cylinder that contains a steam-driven or air-driven **ram.** The ram consists of a **piston** equipped with a **striking head.** The hammer is rested on the butt or head of the pile for driving.

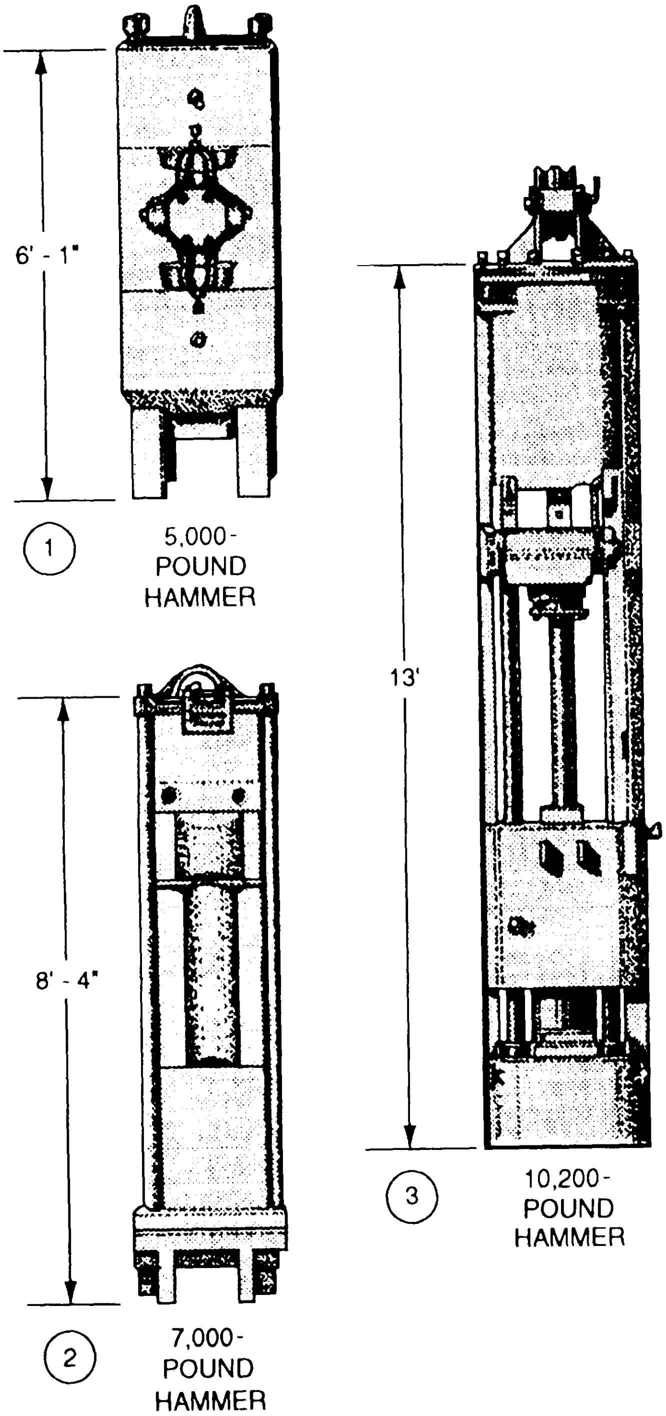


Figure 12-60.— Steam, or pneumatic, pile hammer.

With a **single-action** steam, or pneumatic, hammer, the power drive serves only to lift the ram; the downward blow of the ram results from the force of gravity only. In a **double-action** hammer, the ram is both lifted and driven downward by the power drive. A double-action hammer weighs from 5,000 to 14,000 pounds, and a single-action hammer weighs about 10,000 pounds.

The blows of the double-action hammer are lighter, but more rapid than those of the single-action hammer. The double-action hammer generally drives lightweight or average weight piles into soils of average density. The rapid blows tend to keep the pile in motion, thereby reducing the resistance of inertia and friction. However, when you are driving heavy piles in hard or dense soil, the resistance from inertia and friction, together with the rapid, high-velocity blows of the double-action hammer, tends to damage the butt or head of the pile.

The single-action hammer is best for driving heavy piles into hard or dense soil. The heavy ram, striking at low velocity, allows more energy to be transferred into the motion of the pile, thereby reducing impact and damage to the butt or head of the pile.

A conventional pneumatic hammer requires a 600-cubic-foot-per-minute compressor to operate, and the diesel is a self-contained unit constructed in sizes that deliver up to 43,000 foot-pounds of energy per blow. The diesel pile hammer is about twice as fast as a conventional pneumatic, or steam, hammer of like size and weight.

Diesel Hammer Operation

The most common diesel hammer used in the NCF is the DE-10 McKiernan-Terry pile hammer shown in figure 12-61. The hammer is lifted and started by a single crane load line connected to a **trip mechanism** (A). The hammer is started by lifting the ram piston (B) with the load line until the trip mechanism (C) automatically releases the ram piston. The ram piston falls and actuates the cam of the fuel pump (D) that delivers a measured amount of diesel fuel that falls into a cup formed in the top of the anvil (E). Continuing its downfall, the ram piston blocks the exhaust ports (F) and begins compression of air trapped between the ram piston and the anvil. The compression of the trapped air creates a preloading force upon the anvil, the drive cap, and the pile. The gravity propelled ram piston strikes the anvil, delivering its impact energy to the pile.

The rounded end of the ram piston mates perfectly with the cup in the anvil and displaces the fuel at the

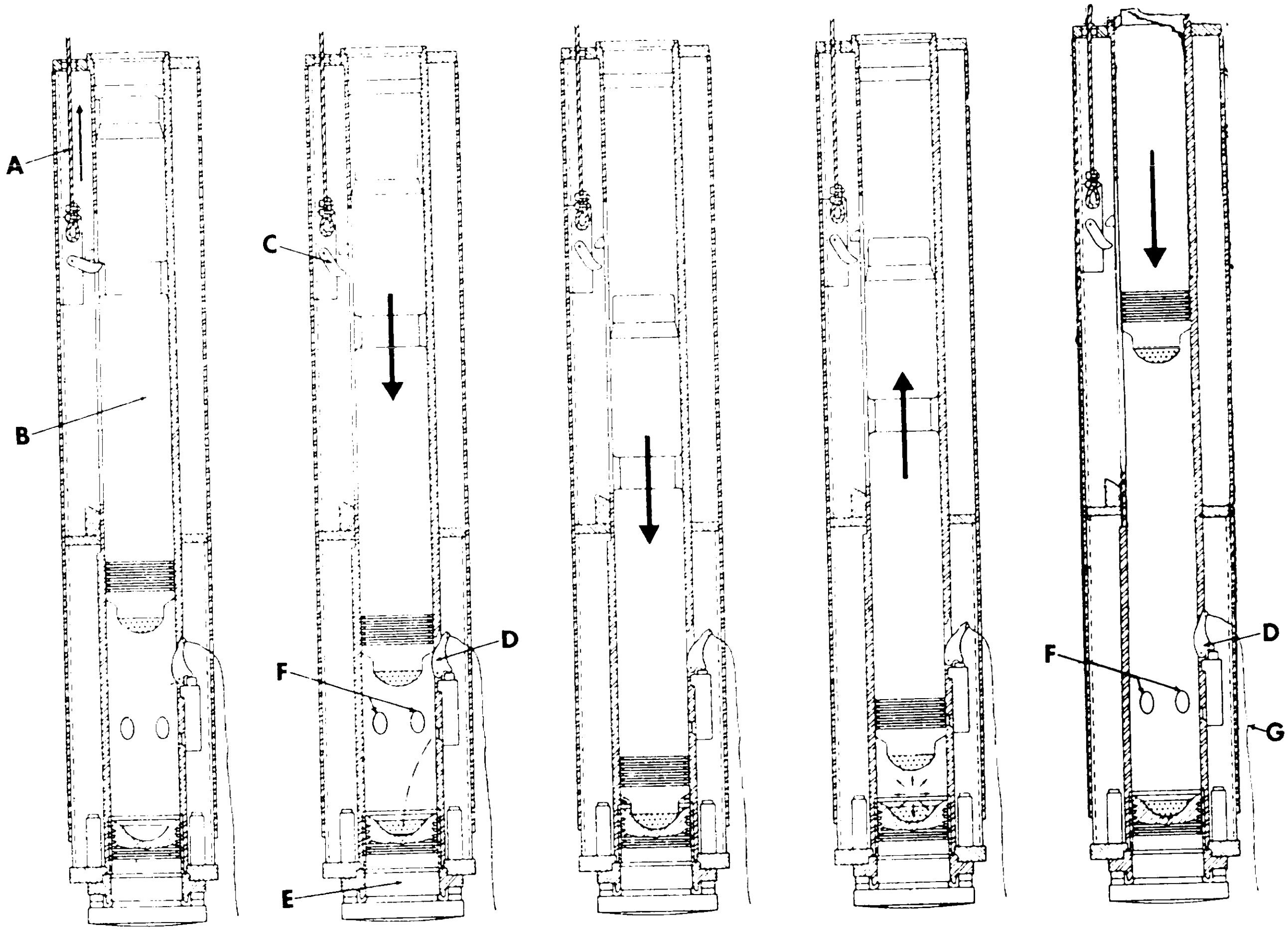


Figure 12-61.-Operating principles of the McKiernan-Terry diesel pile hammer.

precise moment of impact for perfect timing. The fuel is atomized and splattered into the annular (ring-shaped) zone between the ram and the anvil and is ignited by the heat of compression.

The resulting explosive force drives the ram piston upward and the pile downward and adds a push to the pile to extend the time of the total effort to drive the pile.

On the upstroke, the ram piston opens the exhaust ports (F) to permit scavenging the exhaust gases. The ram piston continues freely upward until arrested by gravity. The length of the stroke varies with the resistance of the pile. The greater the resistance, the longer the stroke.

Having reached the top of its stroke, the ram piston falls again, repeating the cycle. The hammer is stopped by pulling a rope (G) that disengages the fuel pump cam (D).

TRIP MECHANISM.— The trip mechanism (fig. 12-62) is an off-center linkage mechanism located at the rear of the hammer, designed to lift and drop the ram for starting. Additionally, the trip mechanism lifts and lowers the hammer in the leads. The trip mechanism is connected to a single line from the crane. Lowering the trip mechanism to the bottom of its stroke engages the lifting lever that lifts the ram. When the crane lifts the trip mechanism and ram piston past the upper stops, the finger of the trip lever is rotated clockwise around the trip lever pin, thus freeing the ram piston. The trip mechanism is held in the upper position while the hammer is in operation.

The safety link in the trip mechanism is designed to break or bend should the operator lower the trip mechanism to low and engage the lifting lever while the hammer is in operation. The safety link prevents damaging the trip mechanism or ram. If the safety link is broken while the hammer is in operation, the hammer will continue to operate; however, once the hammer is shut down, the safety link must be replaced before the hammer can be restarted.

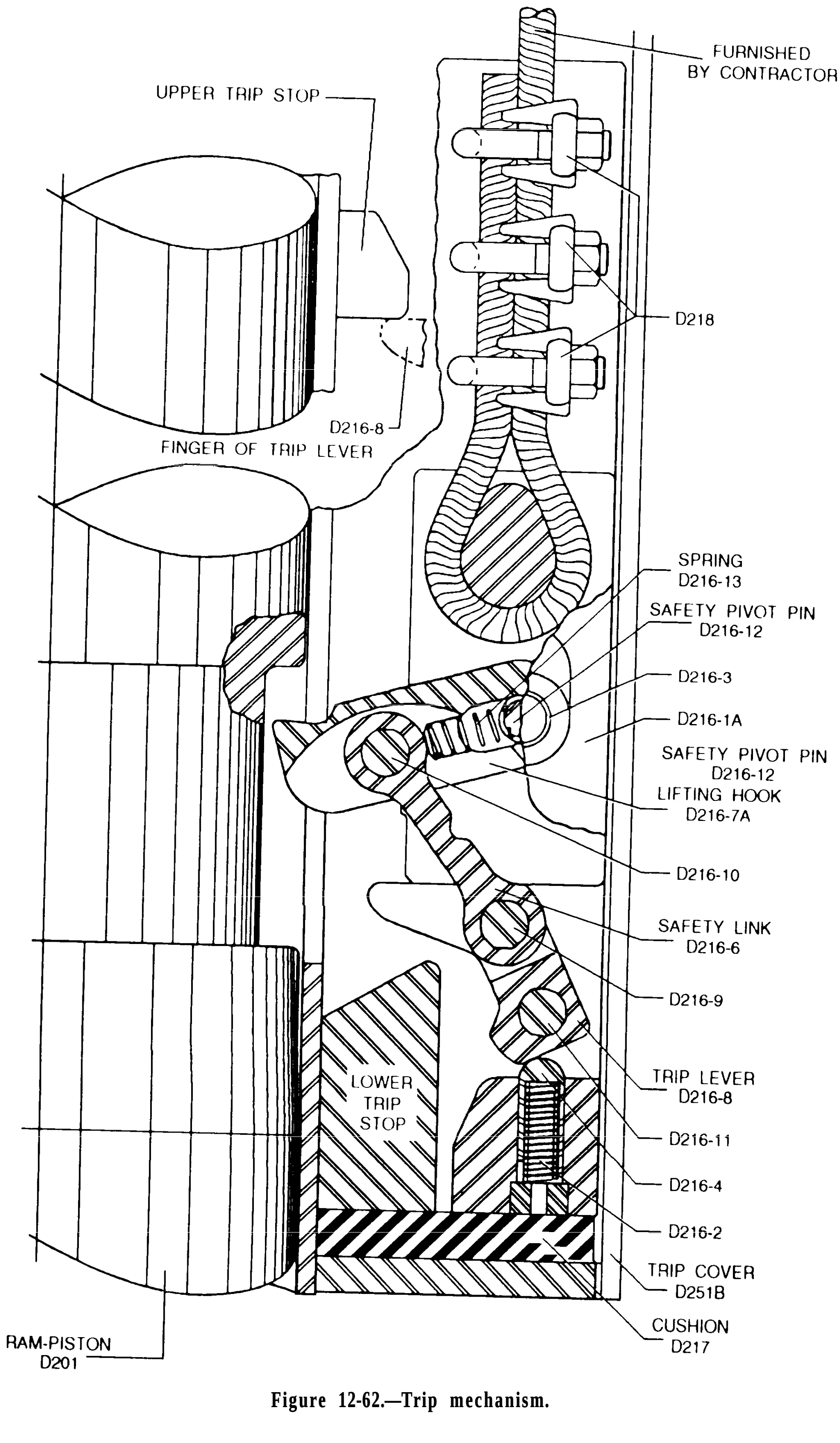


Figure 12-62.—Trip mechanism.

NOTE: The number of safety links to have on hand depends on the experience of the crane operator; however, as a rule of thumb you should have at lease 5 to 10 safety links stored in the toolbox on the jobsite.

FUEL SYSTEM.— Diesel or kerosene fuel is fed by gravity from the main fuel tank through the filter cartridge and in-line shut-off valve and down the inlet line to the pump. The cam-actuated fuel pump is located at the lower end of the cylinder and injects the fuel directly into the combustion chamber in the anvil. The hammer usually consumes about .9 gallon of fuel per hour of operation, and the capacity of the tank is 9 gallons.

LUBRICATION SYSTEM.— Oil drains are fed by gravity from the lubrication tank (fig. 12-63) through the wire mesh falter and in-line shut-off valve down the inlet line to the reservoir in the pump baseplate. From the reservoir oil feeds through passages in the pump to

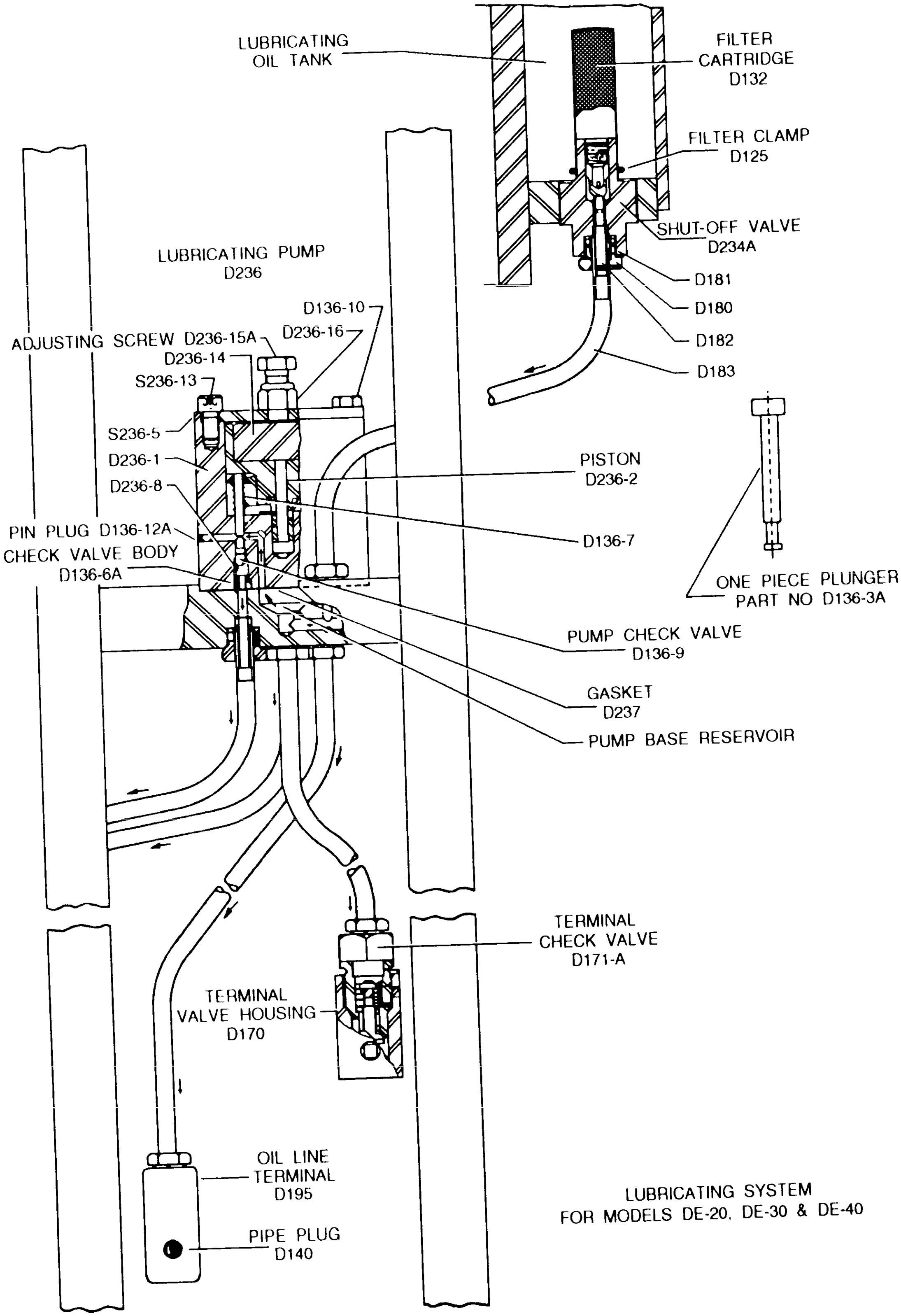


Figure 12-63.-Lubrication system.

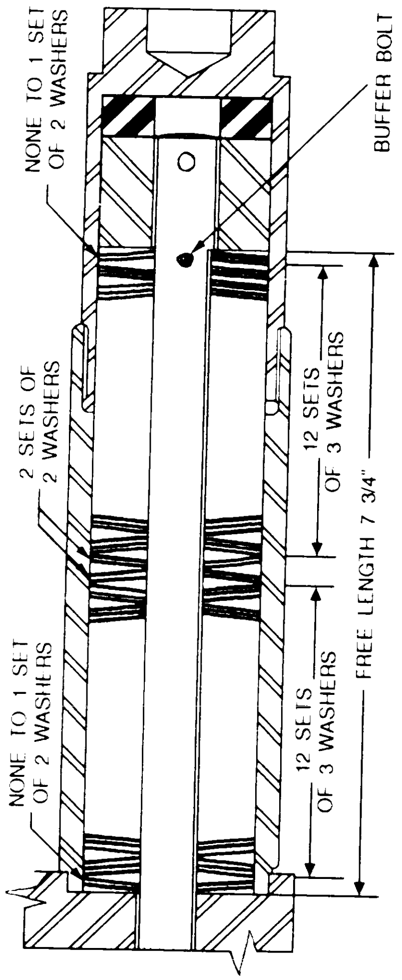


Figure 12-64.-Buffer bolt.

small plungers. A weighted piston rests on these plungers. Ajar of the hammer while in operation forces the piston and plunger down and thus drives a small amount of oil past the ball check valves and into the feed lines. Two of the feed lines have terminal checks that hold back the high pressure of the combustion chamber. A small pipe plug is provided at each terminal to observe the flow of oil.

NOTE: Fill the oil reservoir with **high temperature,** high detergent No. 30 to No. 40 viscosity diesel engine lubricating oil with a flash point of 425° to 450°.

CYLINDER.— The cylinder is a stress-relieved weldment made from steel tubing and plate with a bore specifically chrome-plated to prevent seizing, galling, and rapid wear. The shape of the shell forms a fuel and oil tank as well as protection for the fuel and oil pumps, lines, and trip mechanism. Cover plates, front and back provide easy access to the components. For safety in transporting and rigging the hammer, the ram piston is locked in place by a travel plug found midway on the front of the hammer. This plug should be removed when the hammer is rigged and ready for operation and should

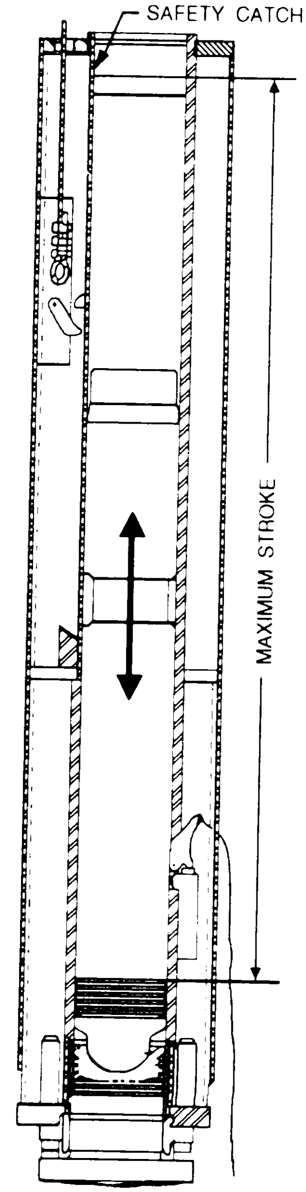


Figure 12-65.-Maximum ram-piston overstroke.

be replaced when the hammer is removed from the leads or is laid horizontal. The ram piston is a chrome-steel forging that has eight compression rings.

BASE ASSEMBLY.— The anvil block in the base assembly group is held in place by buffer bolts and has compression rings identical to those on the ram piston (fig. 12-64). Radial thrust or side thrust to the hammer is transmitted to the leads through the thrust bearing. A vibration damper, concealed under a shroud, isolates the cylinder from the shock vibration of the anvil. Buffer bumpers absorb the recoil from the Belleville washer type of buffer springs connected to the anvil by buffer bolts, dampening overtravel and holding the hammer together. Pins lock the buffer compression nuts to the buffer bolts and are held captive by the buffer housing caps. The buffer nut bumpers absorb the recoil of the Belleville springs.

RAM-PISTON OVERSTRIKE.— The length of free travel (maximum stroke) of the ram from the bottom of the stroke to the safety catch lip at the top is 109 inches (fig. 12-65). When the ram is recoiled high enough, the ram rings will engage the safety catch lip and prevent it from going out of the top. If the upward force of the ram is too great, the whole hammer will be lifted off the pile, possibly causing the rings to shear. To prevent this danger, watch the projection of the ram above the hammer and reset the throttle when necessary.

Pile-Driving Caps

A pile-driving cap is a block (usually a steel block) that rests on the butt or head of the pile and protects it against damage by receiving and transmitting the blows of the hammer or ram. In the steam, or pneumatic, hammer, the cap is a part of the hammer. The cap with a drop or diesel hammer is a separate casting with the lower part recessed to fit the head or butt of the pile and the upper part recessed to contain a hard cushion block that receives the blows of the hammer. The cap is fitted with a wire rope sling so that the cap, as well as the hammer, may be raised to the top of the leads when positioning a pile in the leads.

On the DE-10 hammer, you place one cushion block in the drive cap and lash the cap to the hammer front and back with two pieces of 1/2-inch wire rope and clips. You must allow 3 to 4 inches of slack in the wire rope. The cap is normally lashed to the hammer after the hammer is placed in the leads.

NOTE: The top of the cushion block should be kept high enough to prevent the hammer shroud from fouling on the rim of the drive cap pocket.

Pile-driving caps are available for driving timber, concrete, sheet, and H-beam piles. Figure 12-66 shows a pile cap designed for driving a H-beam pile.

Placing Hammer in Leads

Placing the pile-driving hammer in the leads is performed two ways: while the leads are horizontal or vertical. Leads are not always used in pile-driving operations. Pile hammers can be used as a flying hammer, using special adapter caps attached to the hammer (fig. 12-67). This is far the most dangerous of all types of pile-driving operations and should be attempted only by experienced personnel.

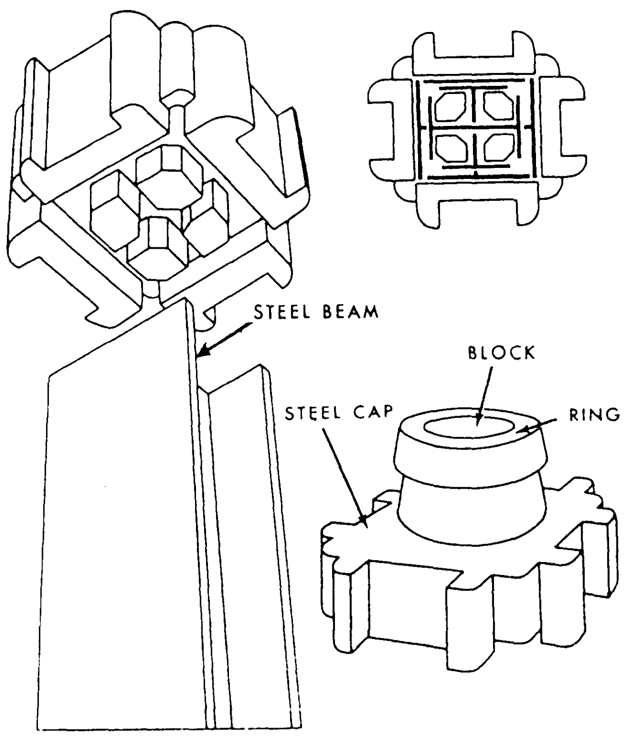


Figure 12-66.-H-beam pile-driving cap.

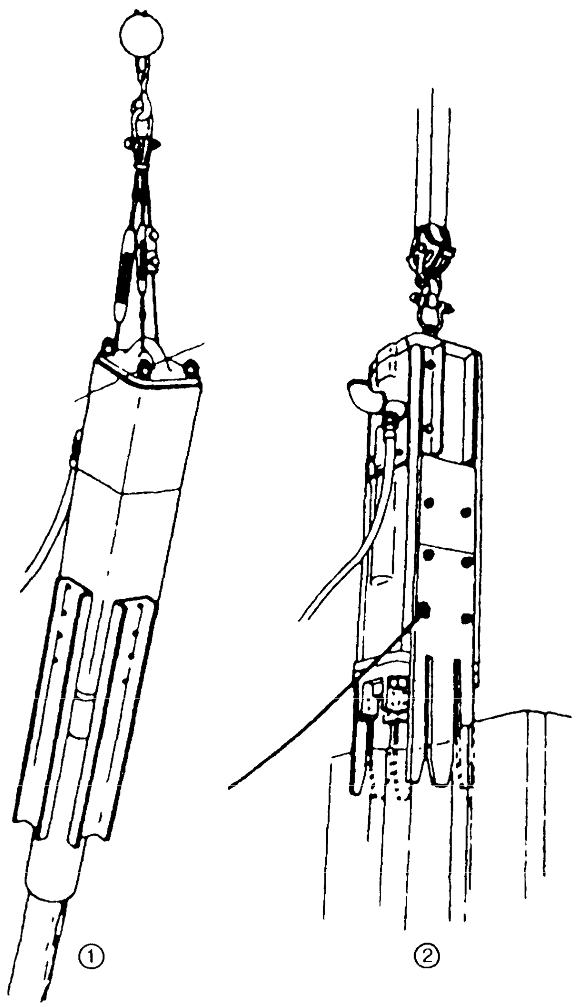


Figure 12-67.—Pile driving using a flying hammer.

The steps required to install the hammer in the leads in the horizontal position are as follows:

1. Block the leads about 18 inches off the ground in several places, keeping them as level as possible.

2. Using a forklift, place the hammer at the base of the leads with the top of the hammer towards the top of the leads.

NOTE: On underhung leads, the fuel pump faces upward. On extended four-way leads, the fuel pump faces downward.

3. Have the forklift approach the hammer from the pile cap end.

4. Adjust the forks so they will just fit the lead guides on the hammer.

5. Pick the hammer up in this manner and guide the top end into the leads as far as it will go without hitting the forks.

6. Block up the hammer that protrudes and reposition the forklift to push the remainder of the hammer into the leads.

NOTE: The crane line may assist in pulling the hammer into the leads.

7. Secure the hammer to the bottom of the leads. This will keep the strain off of the leads, as they are raised to the vertical position by the crane boom.

Installing the hammer in the leads in the vertical position is as follows:

1. Raise the boom and leads from horizontal to vertical and install the catwalk. Continue to raise the boom as high as practical and safety permits.

2. Hoist the hammer to a vertical position and position it under the leads. It takes a combination of lowering the boom and hoisting the hammer to slide the hammer onto the lead guides.

If this does not allow enough clearance to install the hammer vertically, use the following:

1. Use a deep ditch or loading ramp for additional clearance for the hammer.

2, Set the hammer in an excavated hole to clear the bottom of the leads.

3. The hammer can be partially submerged in water to gain additional clearance.

PILE-DRIVING TECHNIQUES AND TERMINOLOGY

Care must be taken during pile driving to avoid damaging the pile, the hammer, or both. The pile driver must be securely anchored to avoid a shift of position. If the hammer shifts while driving, the blow of the hammer will be out of line with the axis of the pile and both the pile and hammer may be damaged.

Carefully watch the piles for any indication of a split or brake below the ground. If driving suddenly becomes easier or if the pile suddenly changes direction, a break or split has probably occurred. When this happens, the pile must be pulled.

Springing and Bouncing

"Springing" means that the pile vibrates too much laterally from the blow of the hammer. Springing may occur when a pile is crooked, when the butt has not been squared off properly, or when the pile is not in line with the fall of the hammer. In all pile-driving operations, ensure the fall of the hammer is in line with the pile axis; otherwise, the head of the pile and the hammer may be damaged and much of the energy of the hammer blow is lost.

Excessive bouncing may come from a hammer which is too light. However, it usually occurs when the butt of the pile has been crushed or broomed, when the pile has met an obstruction, or when the pile has penetrated to a solid footing. When a double-acting hammer is being used, bouncing may result from too much steam or air pressure. With a diesel hammer, if the hammer lifts on the upstroke of the ram piston, the throttle setting is probably too high. Back off on the throttle control just enough to avoid this lifting. If the butt of the timber pile has been crushed or broomed more than an inch or so, it should be cut back to sound wood before driving operations continue.

Driving Bearing Piles in Groups

Bearing piles are frequently driven in groups, as in a pile group which will support a column footing for a building or in closely spaced rows, as beneath a wall. When piles must be driven in closely spaced groups, these principles are observed:

1. When a pile is driven into sand or gravel deposits, the soil must be compacted or displaced an amount equal to the volume of the pile. If the deposit is quite loose, the vibration of pile driving frequently results in considerable compaction of the soil. The

surface of the ground between and around the piles then may subside or shrink. This action may result in damage to the foundation of nearby structures. If piles are driven into dense sand and gravel deposits, the ground may heave.

2. Clay soils are hard to compress in pile driving; hence, a volume of soil equal to that of the pile will usually be displaced (fig. 12-68). The ground will heave between and around the piles. Driving a pile alongside those previously driven will frequently cause those already in place to heave upward. If the piles are driven through a clay stratum to firm bearing beneath, the heave may destroy the contact between the tip of the pile and the firm stratum. Such cases maybe detected by taking a level reading on the top of the piles previously placed. Piles which are raised appreciably should be redriven to a firm bearing. Soil displaced by the pile may cause enough lateral force to move previously driven piles out of line.

3. The sequence of driving piles in groups should be as follows:

- Driving should progress from an area of high resistance to one of low resistance, toward a stream, or downslope to reduce the shoving of previous driven piles that are out of place when succeeding piles arc driven.

- Outer rows in the group should be driven first if the piles derive their main support from friction. Inner rows are driven first if the piles are supported from a point bearing.

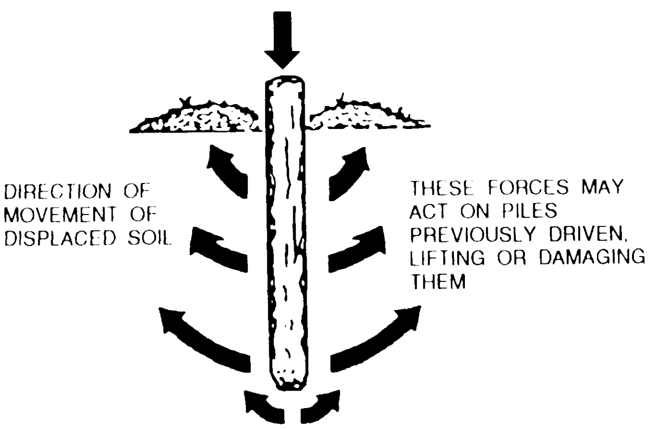


Figure 12-68.-Displacement of clay soil caused by driving solid piles.

Obstruction and Refusal

The condition reached when a pile being driven by a hammer has a 1-inch penetration per blow or zero penetration per blow (as when the point of the pile reaches an impenetrable bottom such as rock) or when the effective energy of the hammer is no longer sufficient to cause penetration (hammer is to light or velocity at impact too little), under which circumstances the pile may cease to penetrate before it has reached the desired depth is known as refusal. Further driving after refusal is likely to break or split the pile, as shown in figure 12-69.

When a pile has been driven to a depth where deeper penetration is prevented by friction, the pile has been driven to refusal. A pile supported by skin friction alone is called a **friction pile.** A pile supported by bedrock or

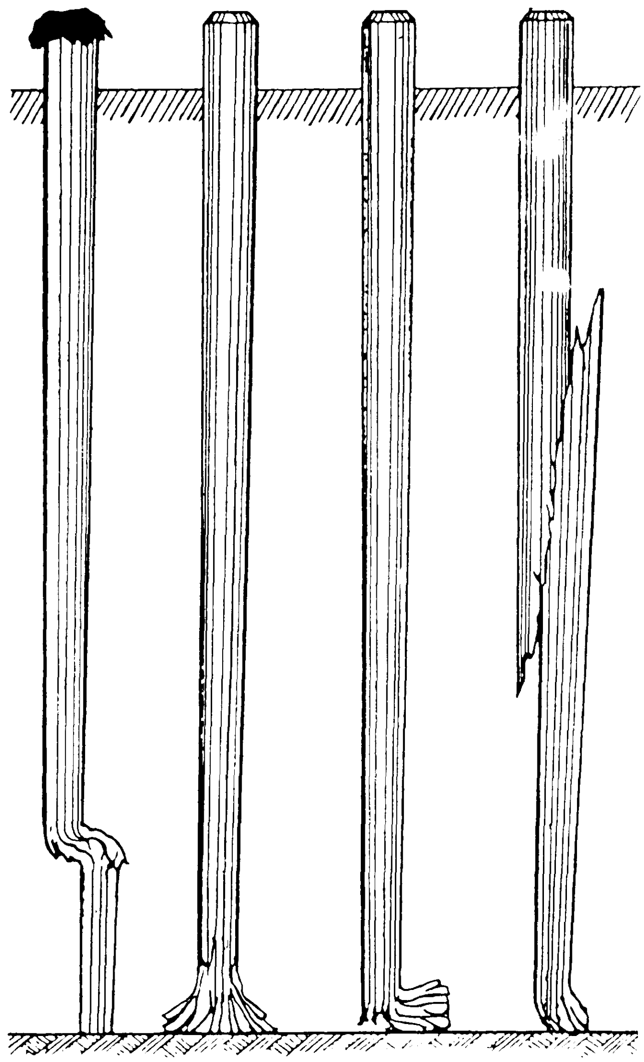


Figure 12-69.—Pile damage caused by overdriving timber piles.

an extra dense layer of soil at the tip is called an **end-bearing pile.** A pile supported partly by skin friction and partly by a substratum of extra dense soil at the tip is called a **combination end-bearing and friction pile.**

It is not always necessary to drive a friction pile to refusal; such a pile needs to be driven only to the depth where friction develops the required load-bearing capacity.

Straightening and Aligning Piles

Piles should be straightened when any misalignment is noticed during pile driving. The accuracy of alignment that should be sought for the finished job depends on various factors, but if a pile is more than a few inches out of its plumb line, an effort should be made to true it up. The greater the penetration along the wrong alignment, the harder it is to get the pile back to plumb.

One method of alignment is to use pull from a block and tackle (fig. 12-70) with the impact of the hammer jarring the pile back into line. The straightening of steel bearing piles must include twisting of the individual piles to bring the webs of the piles parallel to the center line of the bent.

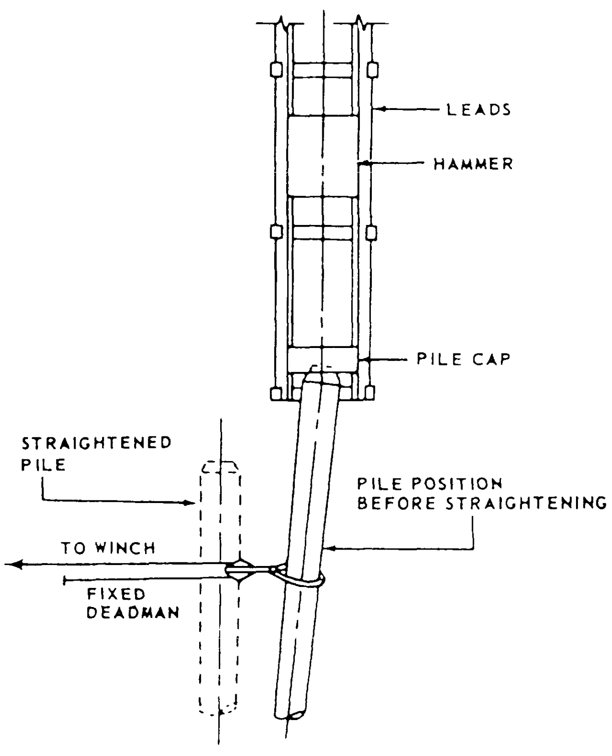


Figure 12-70.-Realigning pile using block and tackle.

Another method of alignment is to use a jet (fig. 12-71), either alone or jointly, with the block-and-tackle method

When all piles in a bent have been driven, they may be pulled into proper spacing and alignment with block and tackle and an aligning frame, as shown in figures 12-72 and 12-73.

Pulling Files

A pile that has met an obstruction, that has been driven in the wrong place, that has split or broken in

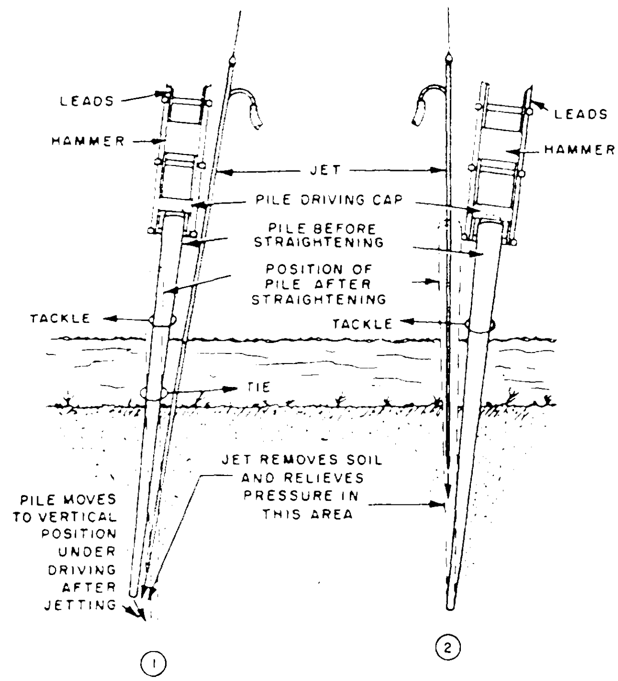


Figure 12-71.—Realigning pile by jetting.

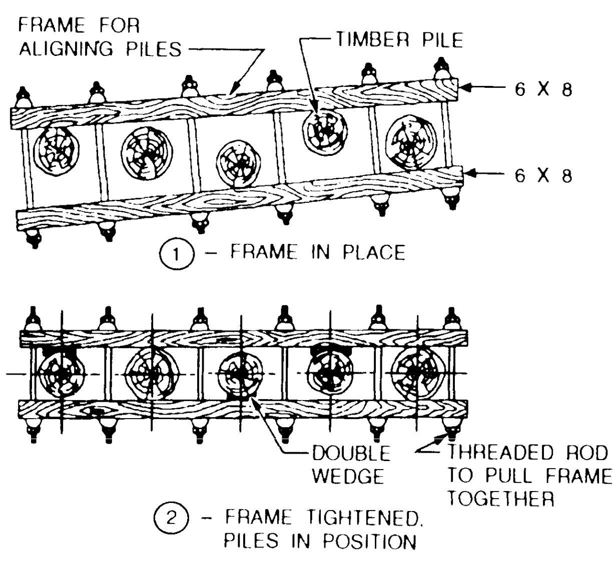


Figure 12-72.—Aligning frame used for timber pile bent.

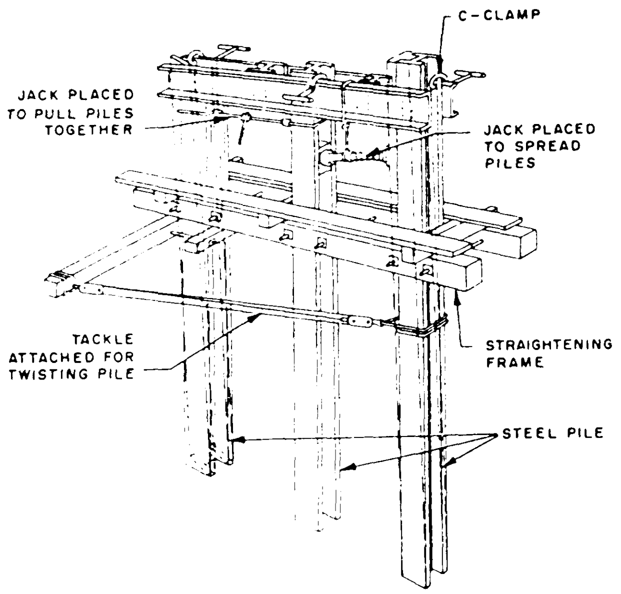


Figure 12-73.—Aligning and capping steel pile bents.

driving, or that is to be salvaged (steel sheet piles are frequently salvaged for reuse) is usually **extracted** (pulled). Pulling should be done as soon as possible after driving; the longer the pile stays in the soil, the more compact the soil becomes, and the greater the resistance to pulling will be. Methods of pulling piles are as follows:

1. In a **direct lift** method, a crane palls the pile. The crane hoist line is rigged to the pile through the use of wire rope rigging, and an increase in pull is gradually applied to the pile. Lateral blows from a **skull cracker** (heavy steel ball swung on a crane line to demolish walls) or a few light blows on the butt or head with the pile-driving hammer are given to break the skin friction, and the crane pull is then increased. If the pile still refuses to extract, it may be loosened by jetting, air extractors, or beam pullers.

2. The 5,000-pound pneumatic, or steam, hammer may be used in an inverted position to pull piles. The hammer is turned over and the wire rope rigging is attached to it and the pile is extracted. A pneumatic extractor may also be used. The crane line, holding the hammer or extractor, is hoisted taut; and the upward blows of the hammer ram on the sling, plus the pull of the crane hoist, are usually enough to pull the pile.

3. Tidal lift is often used to pull piles driven in tidewater. Rigging, wrapped around the piles, is attached to barges or pontoons at low tide; the rising tide pulls the piles as it lifts the barges or pontoons.

Types of Piles

The principal use of piles is for the support of bridges, buildings, wharves, docks and other structures, and in temporary construction. A pile transfers the load into an underlying bearing stratum by either of the following:

1. Friction along the embedded length of the pile

2. Point bearing plus any bearing from the taper of the pile

A pile maybe classified roughly as **friction** or **end bearing,** according to the manner in which they develop support. The load must be carried ultimately by the soil layers around and below the points of the piles, and accurate knowledge of the compressibility of these soil layers is of utmost importance.

Some of the common terms used with piles are as follows:

1. Piles. A pile is a load-bearing member made of timber, steel, concrete, or a combination of these materials, usually forced into the ground to transfer the load to underlying soil or rock layers when the surface soils at a proposed site are too weak or compressible to provide enough support.

2. Pile foundation. A pile foundation is a group of piles that supports a superstructure or a number of piles distributed over a large area to support a mat foundation.

3. Bearing piles. Piles that are driven vertically and used for the direct support of vertical loads are called bearing piles. Bearing piles transfer the load through a soft soil to an underlying firm stratum. They also distribute the load through relatively soft soils that are not capable of supporting concentrated loads.

4. End-bearing piles. Typical end-bearing piles are driven through very soft soil, such as a loose silt-bearing stratum underlain by compressible strata. Remember this factor when determining the load the piles can support safely.

5. Friction piles. When a pile is driven into soil of fairly uniform consistency and the tip is not seated in a hard layer, the load-carrying capacity of the pile is developed by skin friction. The load is transferred to the adjoining soil by friction between the pile and the surrounding soil. The load is transferred downward and laterally to the soil.

6. Combination end-bearing and friction piles. Many piles carry loads by a combination of friction and end bearing. For example, a pile may pass through a

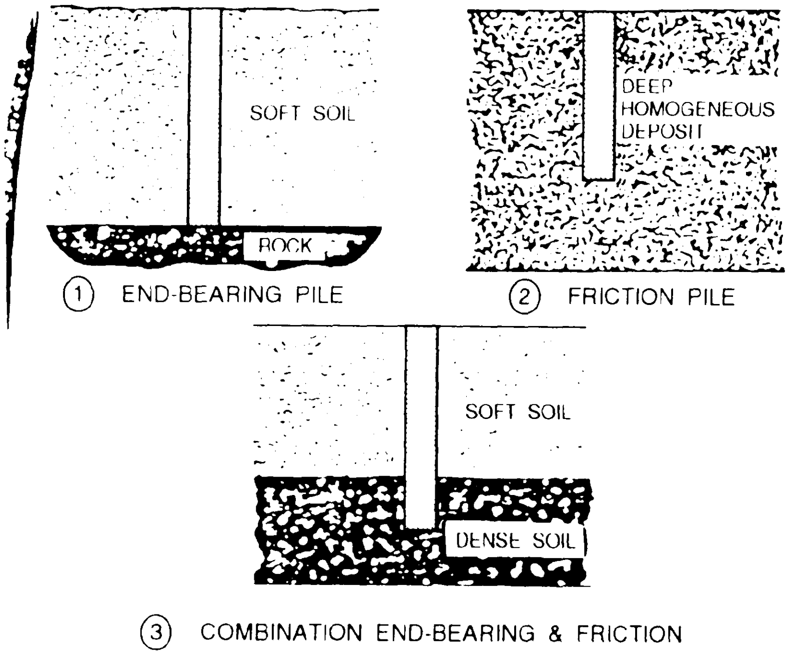


Figure 12-74.—Types of bearing piles.

fairly soft soil that provides frictional resistance and then into a form layer which develops a load-carrying capacity by both end bearing and friction over a rather short length of embedment (fig. 12-74).

7. Batter piles. Piles driven at an angle with the vertical are called batter piles. They resist lateral or incline loads when such loads are huge or when the foundation material immediately beneath the structure fails to resist the lateral movement of vertical piles. They also may be used if piles are driven into a compressible soil to spread vertical loads over a large area thereby reducing final settlement. They may be used alone (battered in opposite directions) or with vertical piles.

8. Anchor piles. An anchor pile may be used to anchor bulkheads, retaining walls, and guy wires. They resist tension or uplift loads (fig. 12-75).

9. Dolphin piles. As shown in figure 12-75, dolphin piles are a group of piles driven close together in water and tied together so that the group will withstand lateral forces, such as boats and other floating objects.

10. Fender piles. As shown in figure 12-75, fender piles are driven in front of a structure to protect it from damage.

11. Foot of pile. As shown in figure 12-75, the foot of a pile is the lower end of a driven pile, which is the smaller end.

12. Guide piles. Piles used as a guide for driving other piles or serving as a support as a wale for sheetpiling.

13. Pile bent. Two or more piles driven in a row transverse to the long dimension of the structure and are fastened together by capping and (sometimes) bracing.

14. Pile foundation. A group of piles used to support a column or pier, a row of piles under a wall, or a number of piles distributed over a large area to support a mat foundation.

15. Pile group. A number of bearing piles driven close together to form a pile foundation.

16. Test piles. A pile driven to determine driving conditions and probable required lengths; one on which a loading test may also be made to find its load settlement properties and the carrying capacity of the soil and as a guide in designing pile foundations.

17. Timber piles. Common timber piles are usually straight tree trunks cut off aboveground swell, trimmed of branches, and the bark removed. A good timber pile has the following characteristics:

Ž It is free of sharp bends, large or loose knots, splits or decay.

Ž It has a straight line between centers of the butt and tip and lies within the body of the pile.

Ž It has a uniform taper from butt to tip.

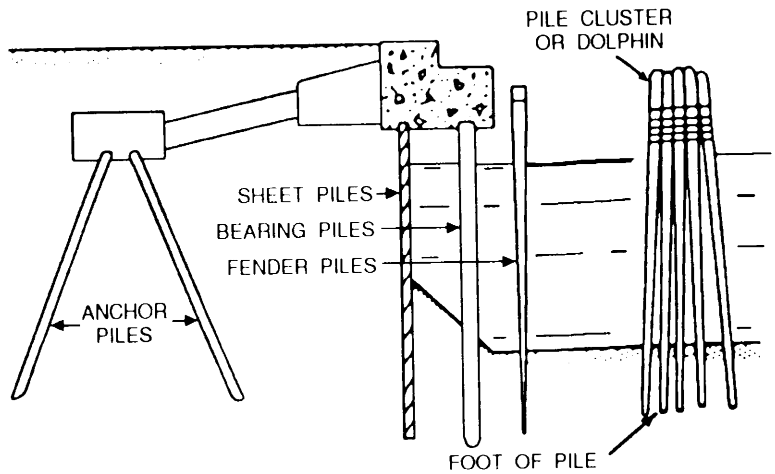


Figure 12-75.—Typical uses of piles driven in a waterfront structure.

18. Treated timber pile. A timber pile impregnated with a preservative material that retards or prevents deterioration due to organisms.

WARNING

When you are working with treated piles, protective clothing, such as long sleeves, gloves, and safety goggles, must be worn. The preservative used in treated piles can irritate the eyes and skin.

19. Concrete piles. Two types of concrete piles are precast and cast-in-place. Factors contributing to their use are the availability of the materials from which concrete is made.

- Precast concrete piles are steel reinforced sections that are square or octagonal in shape except near the tip. They vary in length up to 50 or 60 feet. Because of their great weight, greater lengths are generally not feasible. They require time for setting and curing and storage space. Precast concrete piles are frequently driven with the aid of water jetting (fig. 12-76). Water is forced through and out the pile tip through jetting pipes constructed into the piles while the pile is driven.

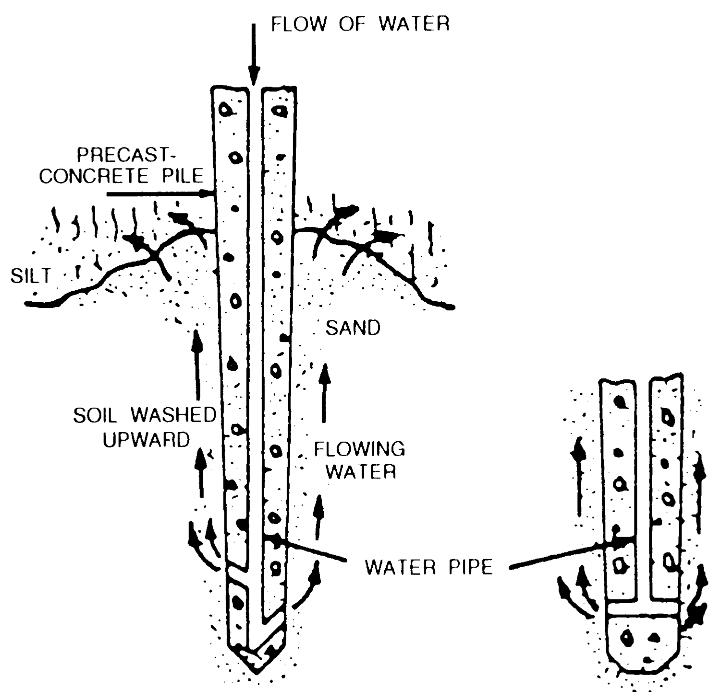


Figure 12-76.—Water jetting precast concrete pile.

- Cast-in-place concrete piles may be used when conditions are favorable. They are made by pouring concrete into a tapered hole or cylindrical form previously driven into the ground or into a hole in the ground from which a driven mandrel has been withdrawn. The left-in-place form may be a steel shell heavy enough to be driven without a mandrel, or it may be a steel form designed for driving with a mandrel that is removed on completion of driving (fig. 12-77).

20. Composite piles. Composite piles are formed of one material in the lower section and another material in the upper section (fig. 12-78). A composite pile that is constructed of wood and concrete is used to support loads of 20 to 30 tons. A composite pile that is constructed of steel and concrete is used to support loads up to 50 tons. As shown in figure 12-78, the first section of wood or steel is driven first, then a mandrel and steel casing are driven on top of the first section. The mandrel is removed and the casing is filled with concrete.

21. Sheet piles. Sheet piles are special shapes of interlocking piles that are made of steel, wood, or formed concrete which are used to forma continuous wall to resist horizontal pressures, resulting from earth or water loads.

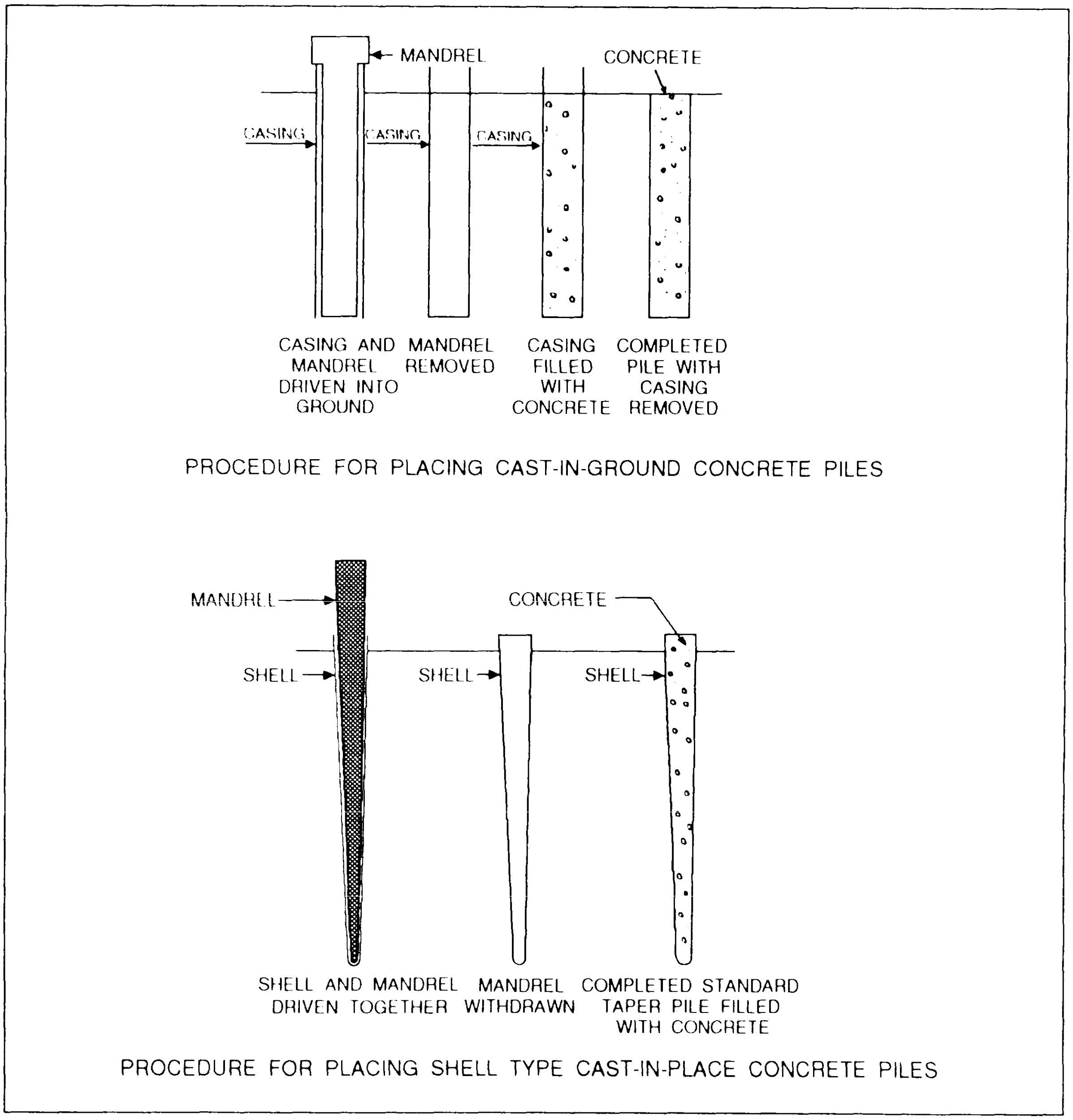


Figure 12-77.—Cast-in-place concrete piles.

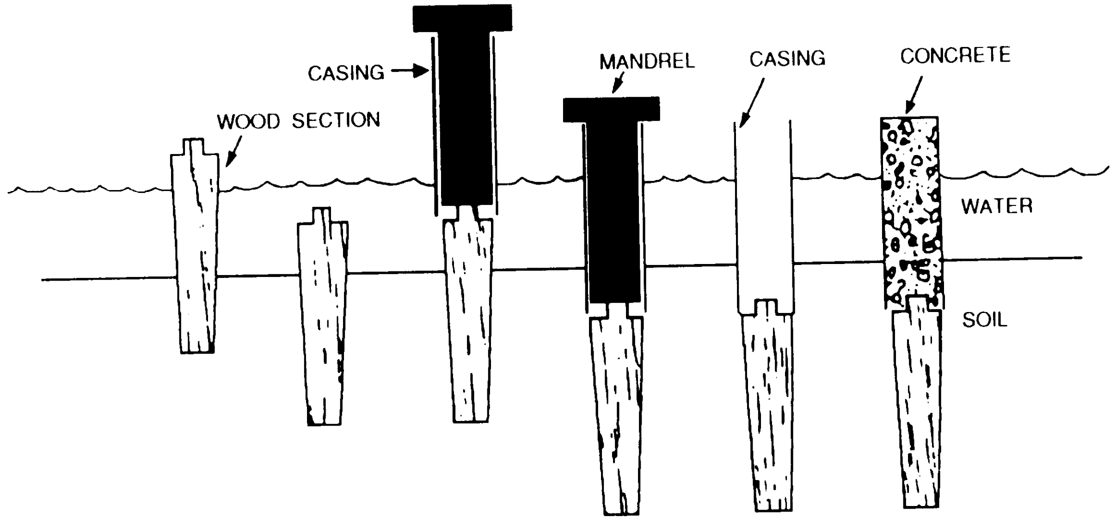


Figure 12-78.-Composite piles.

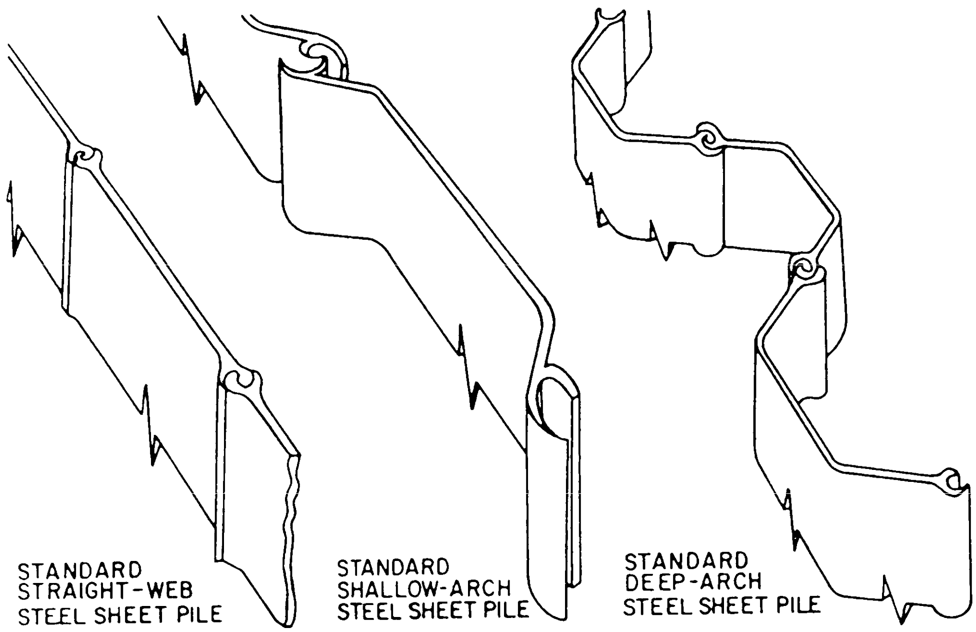


Figure 12-79.—Types of steel sheetpiling.

The most common types of sheet piles are straight-web, shallow-arch, and deep-arch (fig. 12-79).

The straight-web section is designed for maximum flexibility and tensile strength, particularly adapted to cellular cofferdam and retaining wall construction. The shallow-arch and deep-arch sections are multipurpose sections having some resistance to bending.